Contributions to the Comparative Study of the So-called Scombroid Fishes.

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With Plates XIII–XXXIV and 26 Text-figures.

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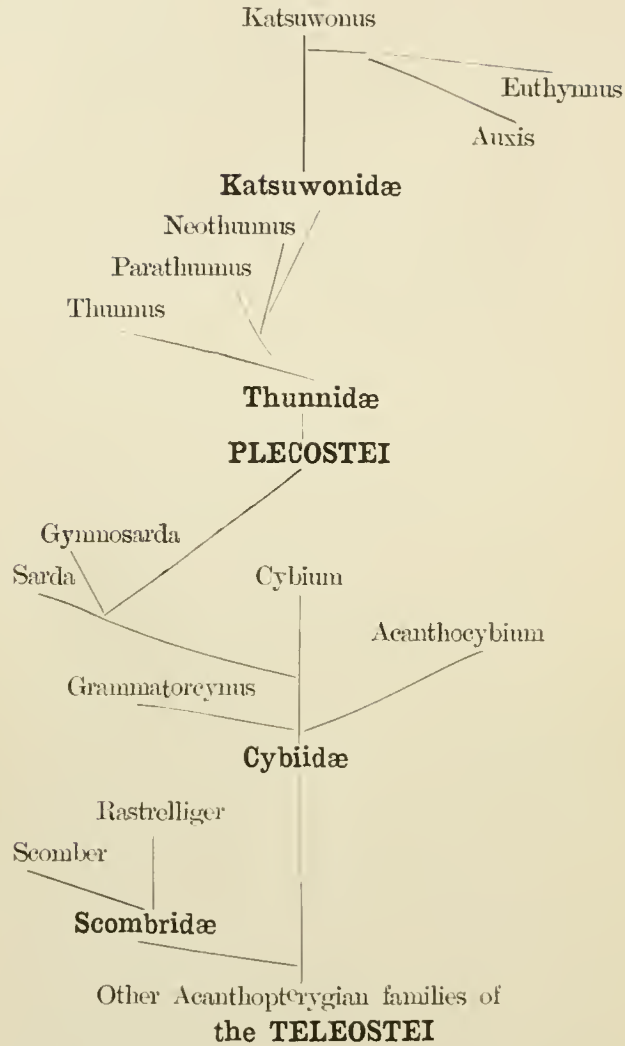


Diagram showing a new scheme of classification, adopted in this monograph, of the genera and families of the so-called scombroid fishes found in Japanese waters, and their probable relations with each other.

Introduction.

Japanese naturalists of olden times, such as EKIKEN KAIBARA (38), JYUBEI KURODA (50), and SHYUSAKU TAKEI (73), arranged the scombroid fishes in four groups:—mackerels, seerfishes, tunnies, and bonitos. Though these authors did not mention the general characters of these groups, I do not hesitate to say that their observations were keen and accurate.

In the occident, LINNAEUS and his followers grouped the scombroid fishes in a single genus *Scomber* without order; but in 1829 CUVIER founded a new classification, and arranged the scombroid fishes (les Scombres) in eight genera:—*Scomber*, *Thynnus*, *Orcynus*, *Auxis*, *Sarda*, *Cybium*, *Thrystes*, and *Gempyles*. This system has been followed by succeeding authors, though more or less altered by them. Thus at present tunnies and bonitos are classified with seerfishes and mackerels together in one and the same family, Scombridæ, and even many recent investigators who have the tendency of dividing old families into many new ones have not yet touched this family. REGAN (62) observed that the definition of the family Scombridæ is not satisfactory, and the natural affinities of different genera are little explained. Recently STARKS (69) tried to solve the mutual relationship of scombroid fishes from the study of the skeleton, and published valuable results.

The scombroid fishes are of great consequence in the economy of our country, ranking next in importance to the clupeoid fishes. Their annual catch amounts to ca. 150,000,000 kg. in weight, and 25,000,000 yen in value. These figures are based on statistical reports from the government, and I believe that they are much underestimated. Of course the amount of catch fluctuates yearly; but there is a tendency to gradual increase, as the fishing grounds are more and more extended. Though these fishes are caught nearly in every part of our empire, and the whole year round, they are more abundant in southern parts, and more on the Pacific coasts than on the Japan Sea coasts. Recently Japanese fishermen have begun to catch tunnies and bonitos in great abundance in the Hawaiian waters and in South California.

The scombroid fishes are mostly migratory, swim near the surface of the sea, and are very widely distributed. They form large schools, grow very rapidly, mostly attaining a gigantic size, and furnish a rich, palatable, nutricious food.

I began the investigation of the scombroid fishes in 1911, and since then I have devoted my time chiefly to this study. As the result of the investigation, tunnies and bonitos were found to be the most specialized forms of the bony fishes with many distinctive characters, hitherto unknown to science. The results have from time to time been reported in Japanese in the "Suisan Gakkwai Hō" (Proceedings of the Scientific Fishery Association).

The materials for the present study were chiefly collected at our laboratory from the fish-markets of Tokyo, and a part from various localities by the author himself, and through the courtesies of institutions and private persons. The author wishes to acknowledge with thanks the kind assistance of Messrs. SEIZŌ ADACHI, YEIJI AKIYAMA, TAKEO AOKI, HIKOTARŌ ASANO, KOICHI KAMEI, NIHEI MATSUNO, the late KŌTARŌ MAYEDA, YŌZŌ NAKAJIMA, SEISHI OKADA, NAOTARŌ OTA, YASUJI OHTA, KATSUYA TAGO, KIYOTOMO TASHIRO, SEIJIRŌ TOMINAGA, YŌJIRŌ WAKIYA, KICHITARŌ YAMADA &c., besides many friends in our College, Imperial Fisheries Bureau, and Suisan Koshyujo; Prof. W. C. M'INTOSH, St. Andrews University, Scotland; the late Dr. RICHARD RATHBUN, U. S. National Museum; Prof. D. S. JORDAN, Stanford University, Cal.; Messrs KŌSAKU IIDA, KIHEI NASU, the late NORIYOSHI TŌYAMA,[1] &c. at Los Angeles; and Mr. E. GOBEE, Fishery Station, Batavia. Finally I wish to express my appreciation of the painstaking work of the artist, Mr. SHIGEZŌ KIKKAWA, who has endeavoured to represent very accurately the various species, and even the number and exact arrangement of scales in each species, and troublesome representations of anatomical structures in detail.

Comparative Anatomy.

EXTERNAL CHARACTERS.

EXTERNAL FORM OF THE BODY.

In general the form of the body is nicely fusiform, so as to give the least resistance in locomotion, but in the case of *Cybium chinense* the anterior part of the dorsal outline is concave (fig. 34). The ventral outline of the body is a little more curved than the dorsal, to balance the heavy muscular part with

1. One of the pioneers who established the tuna fish trade in South California.

the lighter, visceral part. The posterior end of the body is more slender than the anterior, the broadest part of the body being generally in advance of the middle, between the snout and the caudal peduncle. In mackerels the broadest portion is found in the vertical, passing the middle of the first dorsal, that is a little before the middle of the body. In seerfishes the broadest part lies at the posterior part of the first dorsal or near the anus. In tunnies the broadest part of the body is at the middle of the first dorsal, while in bonitos the broadest part nearly coincides with the middle of the body. The body is generally rounded or elliptical in cross-section. In *Rastrelliger* and most species of the genus *Cybium* the body is more or less compressed; but in the Plecostei the body is always plump.

Generally the line connecting the apex of the snout and the middle of the side of the tail passes through the centre of the eye, and nearly coincides with the upper margin of the pectoral fin. In the Scombridæ the nape is narrow, and the body is more or less compressed laterally; in the Cybiidæ the nape is broad, and the body is generally compressed and elongated; while in the Placostei the body is short and plump. In the Thunnidae the nape is broad, but in the Katsuwonidæ it is remarkably narrow. The caudal portion is shorter than the abdominal portion in the Scombridæ; longer in the Cybiidæ, except in the genera *Acanthocybium*, *Sarda*, and *Gymnosarda*; nearly equal in the Thunnidæ; and shorter in the Katsuwonidæ. In the Scombridæ the caudal peduncle is thick, nearly rounded in cross-section and wants the lateral keel, while in the Cybiidæ it is rather thick, more or less horizontally depressed, and is provided with a large lateral keel, which is rather thin and broad at the hind end. In the Plecostei the caudal peduncle is very narrow, depressed, and is provided with a very thick keel, especially in the Katsuwonidæ. In the Cybiidæ these keels are generally covered were elongated scales, but they are quite naked in the Plecostei.

The form of the body differs of course in different ages of fish. Generally the head is longer in small, immature specimens, but the proportion of its length to the height of the body is often constant. Therefore immature specimens of seerfishes and their allied forms, such as *Cybium niphonium*, *C. commerson*, and *Sarda orientalis* are broader than the mature forms; but in the Plecostei the immature forms have a more slender body than the adult. The form of the body differs sometimes in different seasons. Generally the form of the body is fat and fine before the spawning season; but it becomes lean and ugly after spawning, and remains in such a condition during some three or four months. The lean form of *Cybium niphonium* in summer is especially remarkable. This difference of fatness in seasons is little discernible in the case of the Plecostei. In the striped bonito, however, the flesh becomes remarkably watery after spawning, much paler in colour, and at the same time losing both taste and tenacity.

Size of the Body.

Mackerels are generally small, never reaching one metre in the total length. Scerfishes generally grow more than a metre in length, and certain species attain a very large size, for example *Cybium chinense* grows to a length of more than two metres, and to a weight of more than one hundred kg. *Gymnosarda nuda*, *Cybium commerson* and *Acanthocybium solandri* grow very large too. Much larger sizes are rather common in tunnies. *Thunnus orientalis* grows to more than 260 kg in weight, and ca 3 m in length, and even tunnies of 375 kg are recorded. Thus our common tunny is smaller than the Atlantic congener, the latter is said to grow to ca 451 kg in weight. *Neothunnus rarus* is the smallest tunny known, reaching maturity when it is ca 60 cm in length, and 8 kg in weight, being nearly equal to the average size of the striped bonito. In bonitos the size becomes small again, rarely exceeding a metre in length, and 15 kg in weight, the smallest fish of the kind is found in the genus *Auxis*. Fishes of the genus *Auxis* are ca 30 cm long and 600 g in weight.

Colour and Markings.

The back is blackish at the anterior part, changing gradually to bluish or greenish colour, with metallic lustre, and the belly is silvery or greyish, with iridescent reflections. Generally speaking the ground colour of the back is greenish in the Scombridæ, steel-blue in the Cybiidæ, and bluish in the Plecostei. When we observe the living fish, the colour greatly differs from that of the dead, even recently killed. I have observed a remarkable difference in the genus *Auxis*, which is dark bluish green when living, but bluish when dead. The colour of the living fishes is, however, very difficult to observe, as they live rather in off-shore waters, swim very swiftly, and die soon after they are caught. A yellowish colour is found in mackerels and most tunnies, but is not found in fishes of the Cybiidæ, nor in bonitos. Moreover, this colour is not stable in specimens preserved in alcohol or formalin.

Markings are mostly found on the back, and they are generally blackish. They are either irregular, waving streaks, dots, or longitudinal bands, and those found in the back are darker than the ground colour. Markings are sometimes found in the belly too, but they are sooty, fainter than those on the back, or are silvery in the sooty ground. The number of the markings corresponds generally with that of myotomes. Markings on both sides of the body are not strictly symmetrical. Colour and markings fade away in long preserved specimens. On the contrary markings invisible in fresh state may become visible after some days preservation in alcohol or formalin. Colour and markings of the immature forms differ greatly from those of the adult. Generally, immature fishes have simpler and less numerous markings than the adult; but in the striped bonito immature fishes have more numerous stripes than the adult.

Colour and markings become bright, when the fish is excited, and dull, or disappear when frightened.

In our common mackerels pigments are found below the skin, and above the adipose layer, and in the skin which may easily be peeled off, scanty, insignificant pigment-spots only are found. This explains the reason why stale mackerel often retain brilliant colours. In *Rastrelliger chrysozonus* we find a row of dark spots on each side of the base of the dorsal fin, besides two dark longitudinal bands in the back. Two bands below these dark bands and running behind the pectoral are yellowish. The yellowish colour gradually fades in preserved specimens.

Seerfishes have generally two or more rows of dark roundish spots near the lateral median line of the body. In *Cybium niphonium* (fig. 32) we sometimes find the whole body except the back densely covered with spots. In the same species the ventral median line, and a longitudinal line running backward from the base of each pectoral are sometimes coloured black. *Cybium commerson* (fig. 39) and *Acanthocybium solandri* (fig. 31) have many transverse bands, while the fish belonging to the genus *Sarda* have many longitudinal bands on the back (fig. 33). In a small immature specimen of *Sarda orientalis*, obtained on the east coast of Aomori-ken, I found 13 transverse bands, and in these bands, five to seven, oblique longitudinal bands, were found. Fishes belonging to the genus *Gymnosarda* have no markings at all (fig. 37). In the Cybiidæ dots and bands are generally few in number in immature forms, and the markings increase in number by intercalation as the fish grows larger. *Cybium niphonium* under 10 cm in length, and *Cybium koreanum* under ca 20 cm lack markings entirely.

In adult tunnies we find no markings, except many silvery lines and dots in the belly of certain species (fig. 45, 48). These silvery dots and lines are not found in the other scombroid fishes. Adult bonitos have dark bands generally transverse in the back; but they are not conspicuous in the genu *Katsuwonus* (fig. 53), as the bands are very broad and quite near each other. Longitudinal bands on the belly of *Katsuwonus* and dark spots in the thoracic part of *Euthynnus* (fig. 54) are characteristic to the respective genus. Generally small immature forms of plecostean fishes are transversely banded and they extend from the dorsal median line to the ventral median line. These bands are broad and they approach each other very closely, in the Thunnidæ; but in the Katsuwonidæ they are rather narrow, being more narrow than the interval between them, and are short, not reaching the ventral median line. Small immature forms of *Thunnus orientalis* (fig. 43) and *Neothunnus macropterus* have many dark transverse bands, which gradually disappear from the dorsal side, when the fish is about half a year old; but the ventral part of these bands remains all through life (fig. 45). As the fish grows larger, these bands in the belly are subdivided by a series of dots. These boundary lines and series of dots gradually incline obliquely backwards, towards the ventral median line (fig. 45). In *Parathunnus mebachi* of ca. 90 cm in length I found ventral markings, but in larger specimens they disappear entirely. In *Thunnus germo* and *Neothunnus rarus* (fig. 48) irregular longitudinal bands of greyish colour are found in the belly, and they anastomose with each other, leaving silvery meshes. In the former species the marking disappears in larger specimens, but in the latter, it remains lifelong. Pigments and silvery ingredients of bonitos are found at the surface of the skin. Therefore when we peel off the skin, the colouring is mostly lost, and only a thin pale layer of pigment is found above the adipose layer of the body. Sometimes the belly of bonitos is sooty brown. Fishermen believe that such fishes remained on the muddy bottom a long time. In a small specimen of *Katsuwonus pelamis*, ca. 20 cm long, I found 5 faint transverse bands near the lateral medium line, besides the longitudinal bands. These transverse bands are called by fishermen bands of the saurel-type, and when these bands appear on the side of the fish, they are greatly excited to bite so that we can anticipate a great catch. In immature bonitos ca 30 cm long, longitudinal bands are more numerous than in the adult, the auxiliary bands being found near the lateral median line. In immature specimens of *Euthynnus yaito*, ca 13 cm long, we find about eight transverse bands, crossing down the lateral line. These bands are darker and bend a little backward at the dorsal part above the lateral line. In a specimen ca 19 cm long there are about thirteen transverse bands. The course of the dorsal part of the bands above the lateral line now nearly coincides with the boundary line between myotomes. Specimens of such size have one to three dark spots at the pectoral region.

The spinous dorsal, caudal, and the axial side of the pectorals are generally blackish. Ventrals and the anal are pale coloured or nearly colourless. In the Cybiidæ the spinous dorsal is generally black, but in immature forms of some seerfishes it is colourless at the posterior portion. In *Gymnosarda* (fig. 37) the tip of the second dorsal and the anal is colourless. In the *Plecostei* the first dorsal is washed with black at the margin. It is remarkable that fins are more or less yellowish in tunnies; but that colour never appears in the fins of seerfishes and bonitos. The yellow colour is especially conspicuous in *Parathunnus mebachi* and *Neothunnus macropterus*; but not conspicuous in *Thunnus germo* and *Neothunnus rarus*.

HEAD.

Generally speaking the head is large, one fifth of the total length of the body in the Scombridæ, one sixth in the Cybiidæ, and one fourth in the Plecostei. The length of the head is generally more or less longer than the height of the body, even in the case of tunnies and bonitos. Therefore it is very remarkable that the head of *Cybium koreanum* is $1\frac{1}{3}$ times the height of the body (fig. 35). The head is somewhat triangularly pyramidal, as its upper surface is more or less flat and the lateral sides oblique, meeting at the ventral median line. This characteristic form is very well developed in the Plecostei, while it is rather a little modified in the Cybiidæ, as the head is more compressed laterally than in other families, and its top is more or less vaulted.

In the Scombridæ the snout is moderately long, ca. 1/3 the length of head, and the posterior nostrils are slit-like. In the Cybiidæ the snout is much elongated, being nearly equal in length with the part behind the eye. The anterior and posterior nostrils are nearer to each other, than in the Scombridæ and Plecostei, and the posterior nostrils are more or less elliptical and a little larger than the anterior. In the Plecostei the snout is ca. 1/3 the length of the head, but it seems rather short, as the head is broad. In the genus *Auxis* the snout is very short, being only ca. 1/4 the length of the head. The Japanese name for the fishes of that genus is "medika," which means that the eye is near the snout. The antrior nostrils are quite small, and the posterior nostrils are mere slits.

The mouth is terminal, not protractile. In the Scombridæ it is rather wide, the hind end of the upper jaw reaching or passing beyond the vertical from the middle of the eye; and the margin of the upper jaw is mostly formed by the preorbital. The supplementary bone to the maxillary is very narrow and small in this family. In the Cybiidæ the mouth is very wide, the posterior end of the upper jaw generally reaching beyond the posterior margin of the eye. But in *Acanthocybium*, *Grammatorcynus*, and *Gymnosarda* the maxillary scarcely reach the vertical from the center of the eye. In *Acanthocybium* the preorbital forms the posterior part of the upper jaw. The supplementary bone to the maxillary has its posterior end rounded. In the Plecostei the mouth is comparatively small, the posterior end of the upper jaw not reaching the vertical from the middle of the eye. The supplementary bone to the maxillary has a broad straight side at the posterior end. An obliquely downward grove in the skin from the gape of the mouth is deep and conspicuous.

In the so-called scombroid fishes the teeth in the jaws are arranged in one row only. They are a little more numerous in the upper than in the lower jaw. They are formed in alveoles and are replaced by new ones coming out between the old. In the Scombridæ the teeth are very minute. Indeed the Japanese name "saba" for the mackerel means minute teeth in our old language. The vomerine teeth when present are arranged in two lateral patches, and the palatine teeth when present are in one row only. In the Cybiidæ the teeth are well developed, long, curved, laterally compressed, and generally trenchant at the edges. Thus seerfishes are voracious, and often hurt fishermen and damage fishing apparatus too. Teeth on the vomer and palatines are villiform. In the Plecostei the teeth in jaws are small, conical and curved. In the Thunnidæ villiform teeth are found on the vomer, palatines, and pterygoids. Mesopterygoid teeth are remarkable, as they are not found in the other fishes. In the Katsuwonidæ the teeth are found in both jaws only; but in the genus *Euthynnus* palatines and sometimes the vomer too are toothed. In these cases the teeth are arranged in one row only, and they are rather large.

The eyes are comparatively small in the Cybiidæ, being contained more than 7–10 times in the length of the head, and more than 30–40 times in the total length of the body; but they are large in *Gymnosarda*. In the Scombridæ and Plecostei the eyes are large, being contained less than 6–10 times in the head, and 18–27 times in the body. In the Scombridæ the adipose eyelids are remarkably well developed. In the Cybiidæ and Plecostei the eyelids scarcely cover the eye-ball. *Thunnus germo* and *Parathunnus mebachi* have large eyes, these tunnies descend to the deeper strata of waters. The eye-capsules are well developed and more or less calcified in the Plecostei.

Lateral Line.

The lateral line more or less undulates. In the Scombridæ, however, the undulation is insignificant, being nearly straight from the nape to the caudal peduncle, running more or less parallel to the dorsal median line of the body, and the perforated scales in the line are only a little modified from other scales. In the Cybiidæ the lateral line runs generally paralled to the dorsal median line of the body for some distance from the nape, and at the caudal part the lateral line nearly coincides with the lateral median line of the body. These two portions of the lateral line are connected by an oblique portion.

The position of this oblique portion is either under the first dorsal or under the second. In fishes of this family the lateral line often sends out many branches on both sides (figs. 31, 32, 35), and these branches are vertical in *Acanthocybium*, but oblique in *Cybium*. The perforated scales are larger, thicker, and greatly modified in their form, and they may also distinctly be seen on the lateral keel of the caudal peduncle, at the trenchant edge.

The lateral line of *Cybium koreanum* (fig. 35), *C. guttatum* (fig. 61), *Sarda orientalis* (fig. 33), and *Gymnosarda nuda* (fig. 37), differ more or less from the typical form. In *Grammatorcynus* two lateral lines are found on each side of the body (fig. 62). The upper lateral line seems to correspond to the normal lateral line, running parallel to the dorsal median line of the body. The lower lateral line joins the upper with a right angle behind the pectoral, and running down backward approaches the ventral median line, a little behind the ventrals. Thence the line runs parallel to the ventral median line, and meets the upper lateral line, a little anterior to the lateral keel.

In the Plecostei perforated scales are very little modified, and the undulation of the lateral line is not much pronounced; but it has a more or less characteristic feature in different families. It is worthy of note that the lateral line of the Thunnidæ always takes a peculiar course, above the pectoral (figs. 43, 45–48). In this region the course of the lateral line is rather difficult to trace, as the pores are indistinct, few in number, and much separated from each other. The lateral line of *Thunnus orientalis* is typical. The lateral line of the *Katsuwonidæ* has only a slight rise above the pectoral, and has small undulations at the caudal portion. KLUNZINGER (49) wrote in the diagnosis of *Thunnus thunnina* as follows:—

"Die Seitenlinie bildet zuweilen eine Knickung nach oben über der Mitte der Brustflosse; dann senkt sie sich, etwas unregelmässig wellig laufend, bis zur Mittellinie."

This description is well adapted to the lateral line of tunnies, but not proper for that of bonitos. Indeed the author confounded immature tunnies with bonitos, identifying *Orcynus schlegeli* of STEINDACHNER (immature form of our common tunny) with *Thynnus thunnina*.

SKIN AND SCALES.

The skin is thick and well developed, and its deeper layer, the dermis, is composed of several layers of oblique connective tissue, running in two different directions, more or less perpendicular to each other, and alternating in succession. The skin is more or less elastic, and extensile longitudinally, but almost nonextensile transversely. In the Scombridæ we count only two layers of connective tissue in the skin, in the Cybiidæ four layers, and in the Plecostei about six layers.

Scales of the so-called scombroid fishes are generally described as cycloid, but most of them are imperfectly ctenoid, as they are toothed at the posterior margin, and have no striation or only faint striation at the surface. In the Scombridæ scales are nearly cycloid, almost equal in size and form, everywhere in the body, except those scales on the second dorsal, anal, and the middle part of the caudal fin. Scales in these parts are small and slender. In the Cybiidæ scales are small, thin, and are often concealed under the skin or disappear from the most part of the body. The differentiation of scales is more marked than in the Scombridæ; those on the lateral line and those near the dorsal and ventral median lines are longitudinally elongated and densely crowded. Scales at the pectoral region are larger and more or less differentiated to form the corselet. In the Plecostei the corselet is very well developed. Scales in it are very thick, and it is covered by a tough membrane, so that the pectoral region is doubly strengthened, probably to protect the thick portion of the cutaneous blood-vessels, peculiar and very important to the Plecostei. The scales on each side of the base of the first dorsal are pretty large, rhombic, and are arranged in several longitudinal rows. Small elongated scales are found on the external side of the pectoral, and sometimes at the base of the ventrals and on the caudal. In the Plecostei scales round the pectorals are small and elongated. In the Katsuwonidæ scales are not developed outside the corselet; but in an old striped bonito I found minute scales scattered here and there outside the corselet. These scales are roundish and have a few concentric striæ. In the Scombridæ and Cybiidæ small scales are found on the opercular bones; but in the Plecostei these bones are entirely naked. Scales on the cheeks are much modified, elongated and arranged as if radiating from the eye. In the Scombridæ these scales are especially large and unequal in size.

The scales of the Scombridæ are longitudinally striated near the posterior margin, besides the striation parallel to the posterior margin. Scales of the Cybiidæ are mostly concentrically striated, and those of the Plecostei are mostly smooth at the surface and have a dentritic lumen inside. Very narrow scales, arranged longitudinally and very thickly together, are found on the second dorsal, caudal and sometimes on the external surface of the pectoral, contributing to strengthening these fins and at the same time to make their surface more smooth.

Fins.

The fins are generally well developed, stout, rigid, and are adapted for swift locomotion. Some one says that the fins of the male fish are larger than those of the female; but I have no fact material to corroborate it. Like the development of other organs, fins are also best developed in the Plecostei. In the Scombridæ spines and rays in fins are feeble, slender, and fin-rays are transversely articulated as in most teleosteans. In adult forms of the Cybiidæ and the Plecostei, fin-rays are longitudinally divided at the distal end, but not articulated transversely, except in the genus *Grammatorcynus* and in the ventrals. The ventral fins therefore seem to play a not very important part in swimming in these fishes. The spines consist of single consolidated rods; but the rays are composed of two lateral halves.

The first dorsal fin may be entirely folded into a groove. The other median fins may more or less be divaricated in the Teleostei; but in the Plecostei they are nearly solid, and their form and dimension is little altered.

The pectorals are rather high in position, pretty well developed, and when depressed each of them rests in a shallow depression, the dorsal margin of which generally coincides with the line, connecting the centre of the eye with the lateral median line of the caudal peduncle.

When the pectorals are in motion, they are spread out horizontally and their fore margin lies in a straight line, perpendicular to the axis of the body. Thus when we look at *Thunnus germo*, swimming in the sea, spreading its extraordinary long pectorals, we conceive a dragon-fly in flight, hence our fishermen call the albacore "tombo-shibi", meaning the dragon-fly tunny. The number of fin-rays in the pectoral is 18 in the genus *Scomber*, 19–24 in the genus *Cybium*, 25 in *Gymnosarda*, 30–36 in the Thunnidæ, ca 30 in *Katsuwonus* and *Euthynnus*, and ca 25 in *Auxis*. Thus in general the number of fin-rays in the pectoral increases as the structure of the body becomes more complicate, and again decreases as the structure degenerates. The expanse of the pectoral is nearly unchanged, though the number of rays is increased. There is no doubt that the greater number of fin-rays increases the rigidity of the fin itself. In the Scombridæ the pectorals are small, triangular, and are situated a little higher than in the Cybiidæ and Plecostei. In the Cybiidæ the pectorals are also small, often broad at the origin, and more or less crenulated at the ventral margin, as in *Cybium niphonium*, *C. guttatum* and *Gymnosarda nuda*. In *Cybium chinense*, however, the pectorals are large, and rounded at the posterior margin (fig. 34). The form is quite extraordinary. In the Thunnidæ the pectorals are generally long, reaching the origin of the second dorsal, and even pass beyond it. These fins gradually tapering behind, are sabre-shaped. In the Katsuwonidæ the pectorals are small and triangular. They are pointed at the posterior dorsal end. In *Sarda* and Plecostei a special elastic protuberance or rather a ridge is developed at the inner or dorsal side of the root of pectorals to fit tightly to a corresponding groove on each side of the body.

The ventrals are thoracic, moderate in size, always composed of one spine and five fin-rays, and as in many other fishes fit to depressions of the body when folded. These fins seem to be of secondary importance, as their fin-rays remain transversely articulated, and they are reduced in size in the Cybiidæ, being smaller than the anal, except in the genus *Gymnosarda*.

The dorsal is divided into two, first and second, and the posterior portion of the latter is further divided into many finlets. In the Scombridæ the number of finlets is generally 5, in the Cybiidæ 6–9, and in the Plecostei 8 or 9. The first dorsal is never continuous with the second, and is formed of several spines which when depressed are wholly received in a groove. The tip of the spines of the first dorsal is flexible, and each spine has a hole at the proximal end. In the Scombridæ and also in the genus *Auxis* of the Katsuwonidæ, the two dorsals are separated by an interspace from the suppression of some posterior spines, and in these cases the first dorsal is short but rather high, higher than the second dorsal. The first dorsal of the Scombridæ originates from the myotome of the second vertebra, while that of the other so-called scombroid fishes originates from the myotome of the first vertebra. Therefore the origin of the first dorsal in the Scombridæ is well behind the origin of the pectoral fin, while in the other groups the former and the latter lie nearly in the same vertical. In the Scombridæ the spines of the first dorsal are very feeble, and the first spine is shorter than the second, which is generally the longest (figs. 28, 29). In the Cybiidæ the first dorsal is generally low, long, mostly black, and its outline is more or less convex, gradually descending backwards (figs. 31–37, 61, 62). The first spine is not the longest as in the Scombridæ. The first dorsal of *Acanthocybium solandri* differs from that of allied fishes in being broad and of nearly the same breadth throughout (fig. 31). In *Cybium* the height of the first dorsal is 1/4–1/3 the height of the body. In the Plecostei the first dorsal is generally high and the outline of its dorsal posterior side is concave, and its first spine is always longest and thickest, the following spines, though decreasing rather rapidly in length are also strong (figs. 43–48). In the genus *Katsuwonus* the height of the first dorsal is best developed. The longest spine is about 3/5 the height of the body. In other bonitos and most tunnies the height of the first dorsal is contained about twice in the height of the body.

The second dorsal and anal are nearly equal in form and size. The former precedes the latter one myotome in *Scomber* and *Cybium*, and about three myotomes in the Thunnidæ. Fin-rays of these fins grasp the distal segment of the interspinous bone between the proximal ends of their lateral halves. In the Scombridæ these two median fins are respectively smaller than the spinous dorsal, and fin-rays of these fins are feeble and transversely articulated. In *Scomber* moreover an isolated spine is found before the anal as in the Carangidæ. In the Cybiidæ these two fins are pretty well developed, generally higher than the first dorsal, and their fin-rays are thick and nonarticulated. As some anterior fin-rays of these fins are well developed, their form becomes falcate. They are pretty large, well developed in *Cybium koreanum* (fig. 35) and *C. guttatum* (fig. 61); but are poorly developed and small in *Acanthocybium* (fig. 31), *Grammatorcynus* (fig. 62), and *Sarda* (fig. 32). In the Thunnidæ these fins are falcate, conspicuously developed, and interspinous bones supporting fin-rays of these fins are remarkably broad. In some forms of *Neothunnus macropterus* these fins are unusually developed, brightly coloured, and their tips nearly touch the terminal points of the caudal. In tunnies as well as in *Cybium* these fins gradually elongate with the age of the fish. In immature tunnies and also in bonitos the second dorsal and anal are smaller than the first dosral (figs. 43, 53–56). These fins are very small in the Katsuwonidæ, especially in the degenerated genera, *Euthynnus* and *Auxis*.

The caudal fin is strong and lunate. Its two lobes are nearly equal in size and form, but the upper lobe is often slightly larger. In the Scombridæ the fin-rays are soft, thin, and transversely articulated. In the Cybiidæ the size of the caudal is comparatively large, and its fin-rays are thick, and non-articulated. The longest fin-ray in one lobe of the fin makes an angle of ca 60° with the longest in the other lobe. The fin-rays next on each side of the median fin-ray project posteriorly at the middle (figs. 31, 36). In the Thunnidæ the fin-rays of the caudal are so thick and robust, that prehistoric fishermen apparently used it for spear-heads. A specimen of such an implement 21 cm. long, carved from one of these fin-rays of our common tunny, was discovered by Mr. GENSHICHI YENDO in a shell-mound in Miyatojima near Sendai, Miyagi-ken. The angle made by the longest fin-rays in the two lobes of the caudal is more than 90° in the Thunnidæ and Katsuwonidæ. Fin-rays of the caudal of the striped bonito are sometimes used as tooth-picks after being cleaned and bleached. Among the so-called scombroid fishes in our waters the caudal fin is largest in *Cybium chinense*, the length of its upper lobo being longer than the height of the body, and ca. 1/4 the length of the body (fig. 34). In *Cybium guttatum* (fig. 61) the caudal fin is also very large.

SKELETON.

The Scombridæ, Cybiidæ, and Plecostei differ a great deal from each other in the skeleton, the fundamental structure of the body. There seems to be very little relation between the skeleton of the Scombridæ and that of the Cybiidæ; but the gradual transformation of the skeleton of the Cybiidæ to that of the Plecostei is obvious. The skeleton of the Scombridæ is unique in many respects, but it is more or less related to that of the Serranidæ, and it has a remote relation to the Carangidæ. The characters of the skeleton of different scombroid fishes may well be understood by comparing the middle transverse sections of vertebræ, shown in Pl. XVI.

In the Scombridæ the skeleton is weak and brittle. The cranial bones are thin, and not firmly connected together at the anterior part. The vertebræ are notably small, and only a little differentiated in form in different regions of the body (figs. 7, 30). They are rather loosely connected and devoid of deep grooves. The neural and hæmal spines, interspinous bones, and suspensorium of the mandible are narrow and slender. In the Cybiidæ the skeleton is also brittle. The hæmal spine is scarcely developed in the precaudal region (figs. 38–42). The neural spine of some anterior precaudal vertebræ is broad. Except these broad neural spines, the remaining neural and hæmal spines, and interspinous bones are weak and slender. The skeleton of *Sarda* (figs. 11, 42) and *Gymnosarda* (figs. 12. 38) approaches the skeleton of the Plecostei in the development of the lateral keel, in the vertebræ of the caudal peduncle, and the inseparable connection of these vertebræ with each other. Grooves and ridges in vertebræ become conspicuous, and the substance of the vertebræ becomes hard and compact, as the fish is more highly specialized.

In the Plecostei the skeleton is hard, compact, and the cranial bones are very firmly connected. The vertebræ are comparatively large, have many deep grooves, and their differentiation in different regions is remarkable (figs. 13–15, 49–52, 57–60, 64). The neural and hæmal spines of the vertebral column are thick and the interspinous bones are very broad. The development of long hæmal spines in the precaudal region is remarkable. The so-called inferior foramen is very broad, especially in the Katsuwonidæ, forming a basket-work of the hæmal process. In this family the epihæmal spine or bony pedicle of STARKS is particularly developed between the centrum of many vertebræ and their hæmal arch.

SKULL.

In the scombroid fishes the skull is generally triangularly pyramidal, and on the dorsal, posterior part we find five longitudinal ridges or crests. The median ridge is continuous to the occipital crest, separating the right and left lateral muscles, and affording the surface of insertion to the protractor dorsalis at the posterior part. The inner ridge or temporal crest of STARKS and cretes intermediares of CUVIER are found at the mid-dorsal bend of the epaxial part of the lateral muscle, while the outer ridges or pterotic crests separate the lateral muscle from the facial muscles.

In the Scombridae the skull (fig. 30, a, b) is comparatively high, being nearly as high as broad, and is gradually pointed towards the anterior end. The lateral ridges on the dorsal sides of the skull converge forward, and disappear near the posterior margin of the frontals. Moreover there is a pair of short, accessory crests on the external side of the temporal crests. The pterotic processes are stout, sharply pointed and nonflexible. The temporal and pterotic crests are separated by a deep furrow and are connected at the posterior end with a nearly vertical ridge. Nearly the anterior half of the skull is directly under the skin, and is not covered by the lateral muscle.

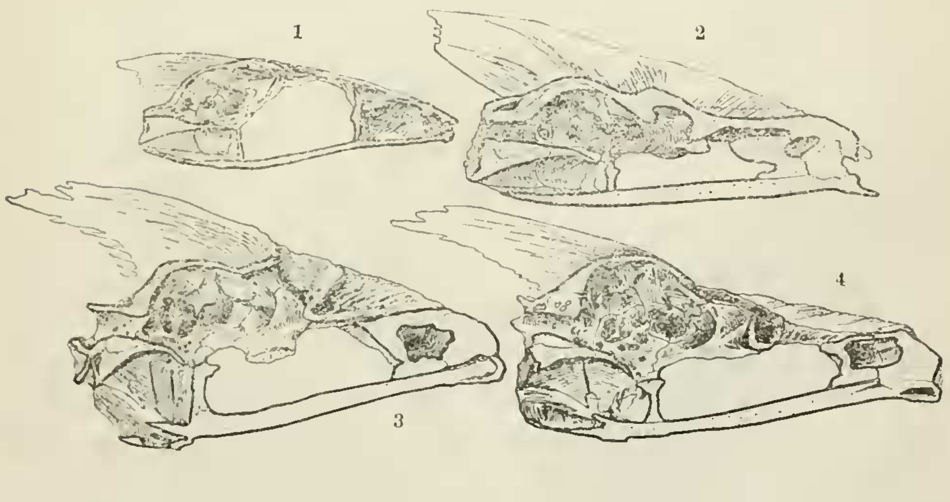


Fig. A. Median sagittal section of the skull. 1, *Scomber japonicus*; 2, *Cybium niphonium*; 3, *Thunnus orientalis*; 4, *Katsuwonus pelamis*. The first vertebra is anchylosed to the skull of *Thunnus*.

In the Cybiidæ the skull is elongated, low, and flat, especially in the ventral, temporal region. Generally the length of the skull is contained more than $1\frac{1}{2}$ times in its breadth. The dorsal crests are well developed, mostly running more than half the length of the frontals, and nearly parallel to each other. In the Plecostei the skull is short, only a little longer than broad, much broader than high, and we find high ridges and deep depressions on its ventral side or the auditory region of MASTERMAN. The development of these ridges and grooves differ greatly in different species. There are three foramina on the dorsal side of the skull, except in the genus *Auxis*. The inner dorsal or temporal crests diverging forward, while the outer ridges are converging; but in the Katsuwonidæ the inner ridges are nearly parallel to each other. The pterotic processes are long, flat, and flexible, especially in the Katsuwonidæ. In the Cybiidæ and Plecostei the posterior ends of the temporal and pterotic crests are connected with a straight ridge on each side of the skull, and the space between these two crests is nearly flat. In the Cybiidæ and Plecostei the dorsal surface of the skull is almost entirely covered with the lateral muscle, except in the cases of *Grammatorcynus*, *Acanthocybium*, and *Gymnosarda*. In the Plecostei there is a special chamber, posterior to the myodome, and below the basioccipital. The sides of the chamber are formed by the parasphenoid. So I shall name this chamber the parasphenoidal chamber. On the ventral side of the cranium, there are very deep depressions in the otic region. These depressions are quite peculiar to the Plecostei.

The ethmoid is a median bone, bounded by the frontals above, by the prefrontals at the lateral and posterior sides, and by the vomer and parasphenoid below. It has paired horn-like processes with a condylar surface for the maxillary at their ventral surface. In the Scombridæ, however, the condylar surface for the maxillary is found it the lateral ventral margin. The dorsal exposed surface of the ethmoid is crescent-shaped or Y-shaped in the Cybiidæ; but it is more or less trapezoidal in the Plecostei. The concavity at the front edge of the exposed dorsal surface of the ethmoid is to receive the premaxillary processes.

The prefrontals are paired bones, forming the anterior wall of the orbit, and lie between the vomer, parasphenoid, ethmoid, and the anterior part of the frontals. Generally they are massive, but in *Scomber* and *Gymnosarda* they are thin bones, folded in different directions. The prefrontals are loosely joined with each other, as well as with other bones, except the vomer. They are longer than broad, and have only one articulating surface for the palatine in the Scombridæ, and also in the Cybiidæ, except *Sarda* and *Gymnosarda*. In these genera and also in the Plecostei the bones are nearly as long as broad, and have no articulating surfaces for the palatine. The olfactory nerve passes through the middle of the prefrontal.

The vomer is an anterior median bone, thickened at the anterior end, but gradually attenuated behind. The bone lies below the parasphenoid, and is joined to it at the posterior part, at the anterior part it is joined to the ethmoid and prefrontals with suture. The ventral surface of the thick anterior end of the vomer is often concave, otherwise nearly flat and is armed with villous teeth. These teeth are grouped generally in a median longitudinal band; but in *Scomber* they are grouped in paired separate patches.

The frontals are large, paired bones, uniting with each other at the median line, and forming a bridge over the orbit, they connect the brain-case with the ethmoidal bones. Their anterior part is thin, flat, and narrow, while the posterior part is broad, and more or less bent downward. From the centre of the dorsal surface of each bone, five striæ radiate in all directions. This central portion is thick. Anteriorly the frontals rest on the entire dorsal surface of the prefrontals and the posterior part of the ethmoid. Posteriorly they articulate with the supraoccipital, parietals, sphenotics, pterotics, and alisphenoids. In the scombroid fishes the frontals do not unite nor meet closely with each other at the posterior end, just above the alisphenoid. In the Scombridæ we find only a slit there, in some fishes of the Cybiidæ the slit is pretty large (figs. 38–40), and in the Plecostei it is large and always conspicuous. Before the slit or foramen the frontals unite with each other at the median line. In the Scombridæ the frontals before the slit are thin, in the Cybiidæ they are thick, and in the Plecostei hollow. In the Thunnidæ near the anterior half of the slit there is a pit with rough walls for the attachment of a ligament connecting the skin to the skull. In the Cybiidæ and Plecostei the lateral external side of the frontal is raised and very thick, while the internal side is raised to form a median crest, continuous to the supraoccipital crest. Thus there is a broad furrow on the dorsal surface of the bone. This character, however, is not found in *Grammatorcynus*. In the Cybiidæ there is a pair of accessory crests between the temporal and pterotic crests, except in *Sarda* and *Gymnosarda*. And this accessory crest is situated rather near the pterotic crest, and is not so conspicuous as in the Scombridæ.

The alisphenoids are paired bones, forming the anterior part of the floor of the brain-cavity, situated on both sides of the ventral median foramen. Generally they do not meet at the median line, but are separated by a large foramen. They are bounded by the frontals at the anterior end, by the sphenotics at the exterior side, by the prootic and basisphenoid at the posterior end, and by the supraoccipital at the dorsal side in *Gymnosarda* and Plecostei. The alisphenoids of the scombroid fishes never come in contact with the prefrontals, though Masterman (56) states that the alisphenoids of the common European tunny extend from the prootics behind to the prefrontals in front. In the Scombridæ the alisphenoids are a little longer than broad, nearly flat, and separated from the supraoccipital. In the Cydiidæ the inner, anterior end of the alisphenoids is more or less turned downward, and in *Cybium niphonium* (fig. A 2) and *C. koreanum* these bones meet in the anterior median line, and are firmly joined together over the root of the olfactory nerve. In the Thunnidæ (fig. A 3) the inner margin of the alisphenoid is produced downward, and meets with that of the opposite side in the median line, to form a median ventral wall, separating the ventral median foramen into two, the small anterior for the olfactory nerve, and the large posterior for the optic. In the Katsuwonidæ the alisphenoids end in a thick pointed process produced along the ventral side of the frontals, and the posterior part is divided into two horizontal sheets. The ventral sheet ends almost free; but in *Euthynnus* it meets with a special broad process of the prootic. In the Cybiidæ and Plecostei the alisphenoid has a dorsal branch at the anterior end. This dorsal branch and the anterior ventral branch grasp the thickened end of the frontal. In the Scombridæ the alisphenoids do not reach the median uniting line of the frontals; but in the Cybiidæ and Plecostei they reach the posterior end of the median uniting line of the frontals and are produced a little further anteriorly below the frontals.

The parasphenoid is a very long bone, running nearly the whole length of the ventral median line of the skull, connecting the otic region with the ethmoidal bones. At the anterior end it rests on the vomer, and is very firmly united with it, and at the posterior end it is embraced by the ventral sides of the basioccipital. For the most part the parasphenoid is entirely free from other bones. At the anterior part the bone is more or less flattened with a dorsal median ridge, and is united to the prefrontals and ethmoid above. At the posterior end of the free portion, the parasphenoid is rhombic in cross-section, having a ventral median keel. Near the posterior end the bone has two short lateral wings to unite with the prootics. At the posterior end, the bone becomes thin, wide, and is bent upwards at the lateral sides. In the Scombridæ the parasphenoid is very slender, and in full grown forms its posterior end nearly closes the foramen between the two ventral wings of the basioccipital. A sharp ventral median ridge is found underneath the otic region. In the Cybiidæ the parasphenoid is rather broad, forked at the hind end, thus leaving a small narrow foramen, which communicates with the myodome. In the fishes of this family as well as of those of the Scombridæ, the posterior part of the parasphenoid is rather flat. The ventral median keel is scarcely developed, except in *Gymnosarda*. In the Thunnidæ the dorsal median keel of the parasphenoid extends to a spot just below the basisphenoid, and is firmly united to the latter at the end of the keel. Generally there is a small ventral median hole near the posterior end of the parasphenoid. It is remarkable that the parasphenoid is broad in the Plecostei, and is turned upwards at the lateral margin of the posterior part, thus forming a special tubular chamber, characteristic to the Plecostei. The chamber lies below the myodome, and is connected to it with a narrow longitudinal slit. Thus the brain-cavity of the Plecostei is much separated from the base of the cranium. The chamber is narrow and pointed anteriorly, but diverges behind, and ends with an elliptical or roundish opening. In the Katsuwonidæ the dorsal median keel of the parasphenoid is not conspicuous at the posterior end of the orbit. The parasphenoidal chamber is better developed in this family than in the Thunnidæ. In *Auxis* the parasphenoid is produced behind as a pair of long horns beyond the occiput. In the Katsuwonidæ the ventral median keel is better developed than in the Thunnidæ.

The supraoccipital is a median bone more or less elongated longitudinally, with a well developed occipital crest. The bone is bounded in front by the frontals, and laterally by the parietals, epiotics, and sometimes by the exoccipitals as well. The posterior part of the bone gradually converges, and lies upon the median suture of the epiotics. The posterior slender portion is often extended over the suture of the exoccipitals. This bone has little characteristics in different families.

The parietals are paired flat bones on both sides of the supraoccipital, and rest on the sutural lines between the supraoccipital, sphenotics, epiotics and sometimes pterotics, taking almost no part in the formation of the roof of the brain cavity. The parietals are surrounded in front by frontals, on the outer side by the pterotics, on the inner side by the supraoccipital, and behind by the epiotics. The parietals are rather small, each with a high, longitudinal crest on the dorsal surface. The crest forms a part of the temporal crest, and is continuous to the crest on the frontals in front, and to the epiotic process behind. In the Scombridae the parietals are provided with two crests. In the Cybiidæ the parietals are generally separated from the pterotics. In the Thunnidæ also the parietals do not unite with the pterotics, at most sometimes touching with a corner above the sphenotics. In the Katsuwonidæ the parietals are united to the pterotics at the outer posterior side, and in the genus *Auxis* the whole outer side of the former bone is bordered by the latter, as in this genus the sphenotics do not appear at the dorsal surface of the skull.

The sphenotics form a part of the lateral wall of the optic lobe, and at the same time a part of the dorsal wall of the optic cavity, externally they are a part of the articulating facet for the anterior head of the hyomandibular, moreover forming the postorbital ridge. The sphenotics are bounded externally by the frontals, alisphenoids, prootics, pterotics, parietals, and epiotics, and internally by frontals, alisphenoids, prootics, supraoccipital, and sometimes epiotics. In *Rastrelliger* the parietals and pterotics are also found round the sphenotics. The sphenotics are generally seen at the dorsal side of the skull, between the pterotics and parietals. In the Scombridæ the sphenotics are found at the dorsal, external side of the cranium, between the pterotic crests. The internal concavity of these bones is subdivided by a septum. In the Cybiidæ the sphenotics are more or less flattened bones and form a very small part in the lateral wall of the brain-cavity, generally with two concavities. In the Thunnidæ the sphenotic has a large concavity inside, and another large one outside. The latter forms the bottom of a deep pit on the ventral surface of the cranium. The dorsal surface of the sphenotic, lying between the temporal and pterotic crests, is divided into two, by a process of the parietal, extending over these bones and joining the anterior, internal corner of the pterotic. In the Katsuwonidæ the sphenotics are nearly like those of the Thunnidæ; but they appear only a little at the dorsal surface of the cranium between the two lateral crests, or they do not appear at all (*Auxis*). Moreover at their ventral surface, we find a depression at the posterior, internal corner.

The basisphenoid is the smallest cranial bone, Y-shaped, median in position, and lies between the prootics and alisphenoids on the cranial floor. The median vertical process is laterally compressed, and is united to the parasphenoid, thus dividing the mouth of the myodome into two. In the Scombridæ the median process is very long, narrow, but in the Cybiidæ and Plecostei it is rather broad.

The epiotics form the dorsal posterior part of the periotic capsule, lying on both sides of the posterior part of the supraoccipital, and anterior to the exoccipital. They are joined posteriorly to the exoccipitals with a rather straight suture, externally to the pterotics, and anteriorly with the parietals, and sometimes with the sphenotics. In the inner side of the cranial cavity, the epiotics are bounded by the supraoccipital, prootics, and exoccipitals, and sometimes by sphenotics as well. They have each a rough prominent epiotic process to unite with the flat dorsal process of the posttemporal. The epiotic process is continuous to the temporal crest; but in *Scomber* the process and the crest are separate. In the Scombridæ the epiotics are markedly prominent as the external posterior ridge of these bones is vertical as in the Serranidæ and Carangidæ; but in the Cybiidæ and Plecostei the ridge gradually slopes downward and outward. In the Cybiidæ a deep groove or a canal is often found in the internal side of the epiotic to receive the anterior semicircular canal of the auditory organ. In *Katsuwonus* we find a triangular process in the internal side of the epiotic to separate the dorsal part of the anterior semicircular canal.

The pterotics are rather thin, more or less elongated bones, forming the lateral posterior corner of the skull, at the corner the bones are pointed, and more or less produced posteriorly to form the pterotic process. On the ventral surface the bones have a large facette for the articulation of the posterior portion of the hyomandibular. There is a protuberance or a process in the midway of the external margin. Anterior to the protuberance the bone forms the posterior part of the outer cranial crest. In the Scombridæ and Cybiidæ the pterotics are flattened and comparatively narrow in the ventral side, but in the Plecostei a special process is produced at the inner anterior corner of the hyomandibular facette, below the ventral groove of the skull. The lateral posterior corner of the pterotics is much produced in the Katsuwonidæ; but the process is not distinct in many forms of the Cybiidæ.

The prootics are seen from the ventral side of the skull only. They meet very firmly at the ventral median line of the brain-capsule. They are bounded by all the cranial bones of the brain-capsule, except the parietals and the supraoccipital. They are very irregular in shape, and rather large. In these bones we can distinguish two lamellæ, horizontal and vertical. In the Scombridæ and Cybiidæ the vertical lamella is nearly smooth and oblique; but in the Plecostei the vertical lamella is high, more or less twisted, and is moreover divided into two parts. These two parts meet in a line over the foramen jugulare in the Thunnidæ; but in the Katsuwonidæ they are not two independent processes in different planes, and there is no foramen jugulare. These bones form the wall of the medulla oblongata and also receive the ventral and nearly horizontal part of the anterior canal of the auditory organ. Generally speaking the bones are more or less flattened exte iorly, but there are two or three deep grooves on the inner side to receive the greater part of the auditory organ. The foramen jugulare lies upon the horizontal bridge. In the Scombridæ and Cybiidæ the prootics take no part in the formation of the hyomandibular cup.

The exoccipitals correspond without doubt to the neural spine of the vertebra and protect the anterior end of the spinal cord, enclosing the foramen magnum. Each exoccipital has a large paraoccipital condyle. The bones may be seen from the dorsal and ventral sides of the skull. They are bounded by the epiotics, opisthotics, prootics, and basioccipital, and sometimes a little by the supraoccipital and pterotics. Each exoccipital diverges anteriorly, and extends also laterally in the Plecostei. In the Scombridæ and *Grammatorcynus* there is an impression of the clavicular ligament on the bone. In the Cybiidæ and Plecostei the bone bears, on the dorsal side, an auxiliary intermuscular bone near the foramen magnum, and sometimes another auxiliary one in a little anterior and superior position. On the ventral side there is a large foramen for the exit of the vagus. In the Katsuwonidæ the exoccipitals are fused at the dorsal margin to form a prominent dorsal median crest, which lies just below the supraoccipital crest. The exoccipital crest is best developed in *Auxis*. On the inner side of the exoccipital, there are two or three grooves anterior to the origin of the spinal cord to receive a part of the auditory organ.

The opisthotics are always found in the so-called scombroid fishes, and are generally seen from the dorsal as well as the ventral side of the skull; but in the Scombridæ they do not appear at the dorsal side of the skull, except the articulating knob for the posttemporal. These bones lie on the exterior side of the exoccipitals, and are bounded by the prootics and pterotics on the anterior and exterior sides. They form a part of the posterior wall of the brain-case. They have a large rough process for the articulation of the hollow end of the lower process of the posttemporal on the dorsal side.

The basioccipital is a bone with a concave occipital condyle behind, and a very deep concavity on the opposite side, lying just below the floor of the foramen magnum. The bone is bounded above by the exoccipitals, in front by the prootics, and ventrally by the parasphenoid. In the Scombridæ and Cybiidæ it is a narrow bone with nearly parallel horizontal sides in the lateral view. In the Plecostei the bone is produced ventrally below the horizon of the vertebral column. This is easily understood if you compare the sideview of skeletons of different families in the accompanying plates. The expanded lateral wings of the basisphenoid overlap the posterior end of the parasphenoid from outside, protecting the parasphenoidal chamber.

The nasals are more or less elongated flat bones, firmly joined to the anterior margin of the frontals, and the anterior end of these bones rests on the palatines.

The preorbitals are also flat, elongated bones with an articulating surface at the dorsal margin to fit to a lateral ventral process of the prefrontal. The dorsal margin of these bones is rather thick, but the ventral margin is very thin. These bones protect the lower side of the eyes.

The suborbital ring of bones is more or less conspicuous in the Scombridæ, but in the other groups of the so-called scombroid fishes the ring is inconspicuous, as the bones of the ring are not much differentiated from scales on the cheek.

Jaw Bones.

In the Scombroid fishes the premaxillary is a long, curved bone, with a long thick head. The bone becomes gradually narrow behind, and without any marked prominence or groove. In the Scombridæ the bone is very thin, slender, and its head is low and blunt. In the Cybiidæ it is massive, and its head is also low. In that family in general the anterior end of the premaxillary is sharply pointed and the dorsal tip of its head is oblique and pointed. In the Plecostei the anterior head of the premaxillary is large, blunt, and thick, while the remaining part is laterally compressed, and comparatively narrow.

The maxillary is also a long, curved bone with a thick hollow head, lying on the premaxillary. The shaft of the bone is thin and narrow at the posterior end, but thick and grooved at the anterior part. In the Scombridæ the maxillary differs greatly from that of the other scombroid fishes. The head is small, its excavation shallow, while the shaft is uniformly flat and broad, and has an indentation at the posterior ventral margin. The dorsal as well as the ventral margins of the bone are trenchant. In the other scombroid fishes the dorsal margin of the maxillary is generally rounded. In the Cybiidæ the head of the maxillary is generally low, grooved at the ventral side for the greater part, and the posterior end of the shaft is broad and flattened. In the Plecostei the maxillary has the head thicker and larger, and the dorsal margin of the shaft is trenchant in the middle, the ventral margin more or less grooved. The auxiliary bone to the maxillary, called jugal by Masterman, is very small, narrow, and insignificant in the Scombridæ; but in the other families of the scombroid fishes it is comparatively large and broad. It is pointed at the anterior end and attached to the dorsal posterior corner of the maxillary.

The palatine lies on the external side of the vomer and holds the head of the maxillary fast, with the bent and nearly bifurcated anterior end. In the Scombridæ the bone is nearly flat in the plane of the mesopterygoid; but in the other scombroid fishes its free ventral margin is generally armed with teeth on a ridge, projecting and more or less vertical to the principal part of the palatine, and also to the plane of the mesopterygoid.

The pterygoid is generally a T-shaped bone, united to the palatine with a slender horizontal shaft. The posterior end is expanded and joins to the inner side of the metapterygoid and quadrate, with a rough surface.

The mesopterygoid is a flat thin bone united to the palatine and pterygoid, and rests on the parasphenoid with the internal free margin. It is very remarkable that the bone is armed with an elliptical patch of villous teeth at its centre in the Thunnidæ, as the bone is not armed with teeth in other fishes.

The hyomandibular is a stout bone, with a broad upper portion, and a more or less rod-like lower portion. The broader portion has three conspicuous condyles, of which the anterior and middle are for the cranium, and the posterior one for the opercle. In the Scombridæ the hyomandibular is broad,

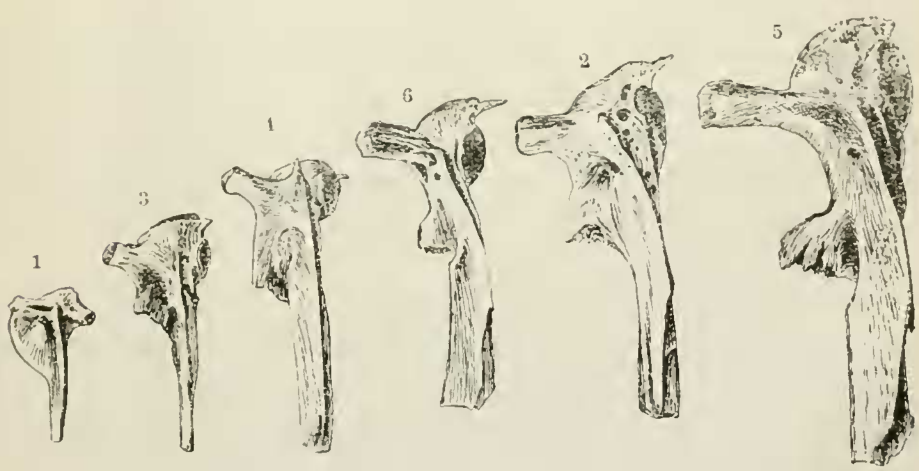


Fig. B. External view of the hyomandibular. 1, *Scomber japonicus*; 2, *Acanthocybium solandri*; 3, *Cybium niphonium*; 4, *Sarda orientalis*; 5, *Neothunnus macropterus*; 6, *Katsuwonus pelamis*.

and the anterior margin of the upper broad portion convex and entire. The condylar protuberances are rather small, not prominent, the anterior one scarcely produced beyond the broad lamellar part, but the posterior one remarkably outstretching behind. Moreover these protuberances are nearly in one plane. The stem of the hyomandibular is grasped by the bifurcated end of the metapterygoid. In the Cybiidæ the upper portion of the hyomandibular becomes narrow, and the anterior condyle is conspicuously produced beyond the lamellar portion. The lower portion is rod-like, and the exterior longitudinal ridge for the attachment of the preopercle is rather prominent, and is produced sometimes beyond the dorsal margin of the broad portion. The posterior condyle approaches the middle condyle, and the former is more or less turned exteriorly. A small pointed process is found behind the middle condyle in the scombroid fishes, except in mackerels. The anterior vertical margin of the upper portion is free; but its lower margin is horizontal and dentate for the articulation with the metapterygoid. In the Plecostei the lamellar portion has become very narrow, but the lower articulating margin for the metapterygoid is broad, so that the lower margin greatly projects. The lower portion is bent a little forward, and is flat and broad, especially in the genus *Auxis*. The exterior posterior longitudinal ridge for the attachment of the preopercle is oblique, and does not reach the dorsal margin of the broad part. The small secondary ridge is developed behind the first, and below the posterior condyle. The last condyle is best developed and is turned exteriorly. The process carrying the anterior condyle is more or less roundish in cross-section in *Thunnus*; but more or less flattened in *Parathunnus* and *Neothunnus*, and in the Katsuwonidæ the process is turned at the dorsal and ventral margins. The lower half of the hyomandibular is broad, flattened, and very thin in the Katsuwonidæ.

The metapterygoid is a broad bone, with the dorsal end bifurcated to grasp the stem of the hyomandibular, and borders the quadrate with a broad, smooth margin, being connected with a narrow intervening cartilage. The shape of the bone differs only a little in different kinds of the scombroid fishes. In *Rastrelliger* this bone is attached to the pterygoid. In *Scomber* the inner branch of the bone extends even over the preopercle. Generally speaking the bifurcation of the bone is not conspicuous in the Cybiidæ. The metapterygoid and quadrate are firmly connected by the intervention of the pterygoid and symplectic, with which they unite with zigzag sutures at the inner side.

The quadrate is a flat triangular bone, with a stout, movable, saddle-shaped joint at the anterior angle to articulate with the lower jaw. At the lower side there is a shallow groove to receive the lower, anterior portion of the preopercle.

The symplectic is a small bone, styliform at the anterior portion which is wedged into the lower part of the quadrate, more or less flattened at the posterior part, but thickened at the lower margin, and connected with the lower end of hyomandibular by a cartilage.

The articular is a stout bone with a long pointed middle process which is partly sheathed in the dentary, two diverging processes at the dorsal and ventral sides, and a large concave articulating surface for the quadrate, above the knob at the hind end.

The angular is a very small bone, firmly joined to the lower posterior corner of the articular.

The dentary is laterally compressed, forked behind, and always carries only a single row of teeth at the trenchant edge. In the Scombridæ the two branches diverge behind, the lower branch being equal to or a little longer than the upper branch. Moreover the lower branch is broader than the upper in *Scomber*. In the Cybiidæ the bone is comparatively narrow, not diverging, and the lower branch is rather shorter and narrower than the upper, except in *Sarda* and *Gymnosarda*. In these genera and also in the Plecostei the bone diverges; but the lower branch is narrower than the upper, and the two branches are nearly equal in length.

Opercular Bones.

The opercle is a flat bone, more or less trapezoidal in form, articulating to the hyomandibular, and is situated behind the preopercle, and above the subopercle. The opercle is rather larger, as the gill-opening is very wide. The anterior angle of the bone is formed by the articular cup for the hyomandibular, and the posterior angle is the dorsal end of the line of union with the subopercle. Generally the dorsal and ventral anterior margins and the diagonal,

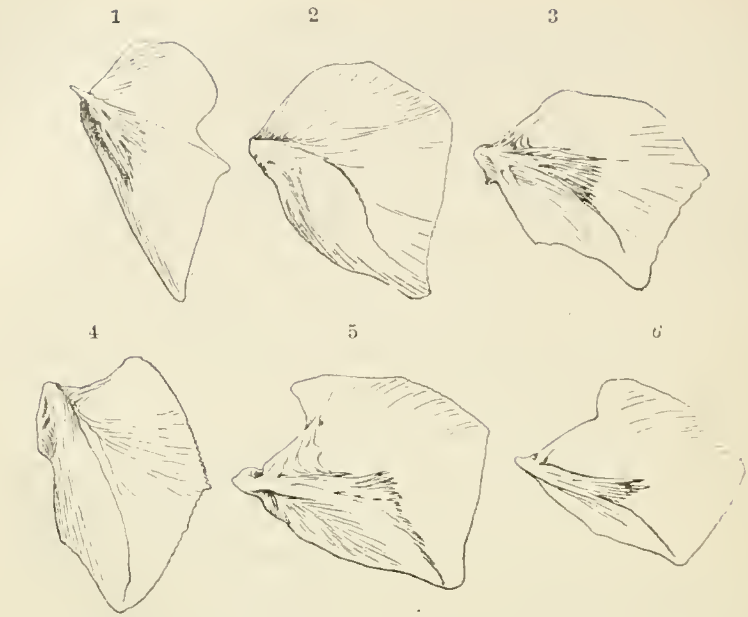


Fig. C. External view of the opercle. 1, *Scomber japonicus*; 2. *Cybium niphonium*; 3. *Sarda orientalis*; 4, *Gymnosarda nuda*; 5, *Thunnus orientalis*; 6, *Auxis maru.*

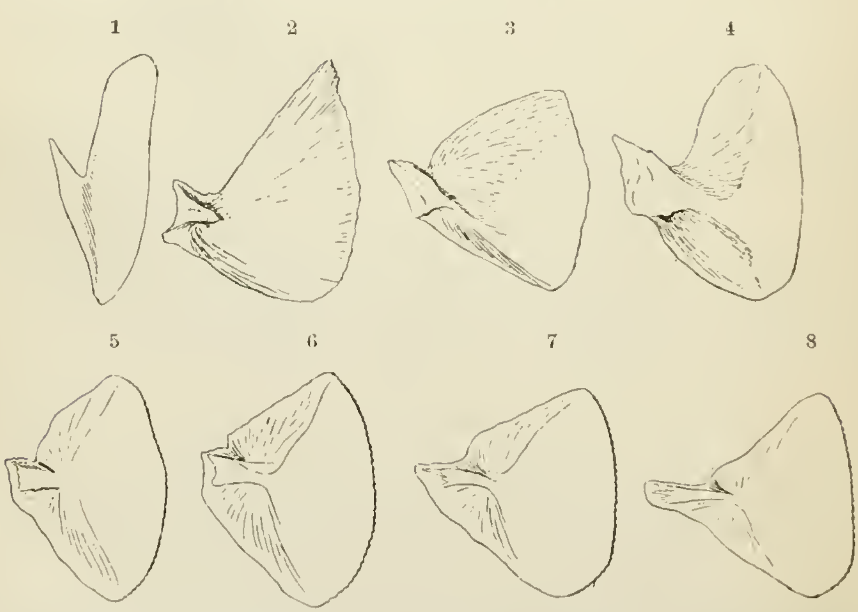


Fig. D. External view of the subopercle, 1. *Scomber japonicus*; 2. *Cybium niphonium*; 3, *Sarda orientalis*; 4, *Gymnosarda nuda*; 5, *Thunnus orientalis*; 6, *Neothunnus macropterus*; 7, *Katsuwonus pelamis*; 8, *Auxis maru.*

connecting the anterior and posterior angles are strengthened by thick ridges. In the Scombridæ the opercle is thin, rather narrow, and the lower angle is acute, while the upper and posterior angles are rounded. The dorsal posterior side has an indentation just above the posterior angle. The dorsal portion i.e. the portion above the horizontal diagonal is smaller than the ventral portion. The articular cup is more or less rounded with a sharp tooth at the anterior dorsal margin. In the Cybiidæ the opercle is rather broad, and more or less pentagonal. The dorsal portion is smaller and thinner than the ventral. The dorsal angle is rounded, and the posterior sides are more or less serrated. The ventral anterior side is not straight. The articular cup is narrow and elongate. In the Plecostei the opercle is thin but firm, and nearly quadrate in form, so that the dorsal and ventral portions are nearly equal to each other. The dorsal anterior side is concave. The articular cup is ellipsoidal.

The subopercle is more or less triangular, its upper side being overlapped by the opercle, and the anterior side by the interopercle, while the posterior side remains free. In the Scombridæ the subopercle is very narrow, and bifurcated at the dorsal end. The anterior branch is short and pointed. In the Cybiidæ the bone is broad, its anterior branch is also broad and sometimes two-horned, except in *Sarda* and *Gymnosarda*. In the Thunnidæ the anterior branch is abortive and the whole bone is nearly obovate. In *Thunnus orientalis* and also in *Th. thynnus* of the Altantic, the subopercle is more or less crenulated or concave at the anterior margin; but in other tunnies the anterior margin of the subopercle is convex. In the Katsuwonidæ the anterior branch is produced anteriorly and nearly horizontally, ending with a blunt end.

The interopercle is an ovate bone, forming the ventral free margin of the gill-cover with fine serrature. The bone is connected by a ligament to the posterior end of the hyoid arch. The interopercle of *Thunnus orientalis* has its posterior margin convex, while that of the other Japanese tunnies has its posterior margin nearly straight.

The preopercle is a large bent bone, of which the vertical limb fits closely against a groove of the outer margin of tho hyomandibular, and the horizontal limb to the metapterygoid and quadrate. In the Scombridæ this bone is the largest opercular bone, broadest at the middle, and tapering gradually and nearly equally towards both extremities. In the Cybiidæ the horizontal limb is wide near the dorsal end. In the genus *Cybium* the preopercle is very broad at the lower posterior angle. In the Thunnidæ the horizontal limb is well developed; but smaller than the vertical. In the Katsuwonidæ the horizontal limb is better developed than the vertical, and both limbs taper nearly equally towards the extremities. The posterior and ventral margins of the opercular bones are attenuated and roll inward when dried.

Hyoid Arch.

The glossohyal is a small median bone, embedded in the substance of the tongue, with a narrow cartilage at the broad anterior end. In the Scombridæ the bone is especially small, and more or less spatulate. In the Cybiidæ the bone is generally rod-like, thick at the proximal part; but in *Sarda orientalis* it is spatulate. In *Gymnosarda nuda* the glossohyal is nearly covered from both sides with the inner edge of paired semicircular dentigerous ossicles. The front margin of the glossohyal is nearly straight in the Plecostei. In the Thunnidæ the glossohyal is spatulate, slightly concave above and below, and constricted at the posterior end. In the Katsuwonidæ the bone is also spatulate, slightly concave in the cross-section.

The hypohyal forms the symphysis with its fellow of the other side

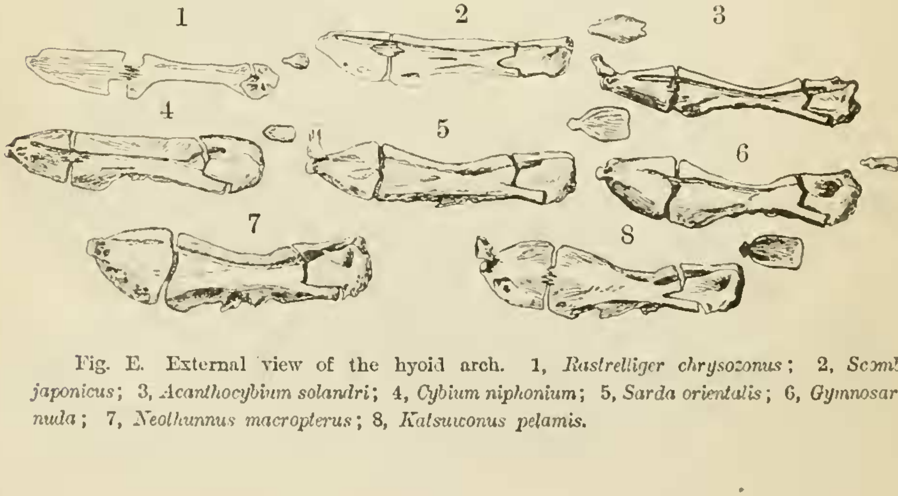


Fig. E. External view of the hyoid arch. 1, *Rastrelliger chrysozonus*; 2, *Scomber japonicus*; 3, *Acanthocybium solandri*; 4, *Cybium niphonium*; 5, *Sarda orientalis*; 6, *Gymnosarda nuda*; 7, *Neothunnus macropterus*; 8, *Katsuwonus pelamis*.

behind the glossohyal, and is composed of two pieces, upper and lower. The former is narrow, while the latter is broad. In the Scombridæ the lower piece has a pair of processes at the posterior margin, growing just in opposition, to grasp the anterior end of the ceratohyal. The inner process is broader than the outer. In the Cybiidæ the lower piece rest partly on the anterior lower process of the ceratohyal. In the genus *Cybium* the posterior upper corner of the upper piece is produced to a pointed process. In the Thunnidæ the upper piece is largely covered by the lower piece from the exterior side. The posterior margin is nearly straight. In the Katsuwonidæ the lower piece has a posterior process which fits tightly to a horizontal slit at the anterior part of the ceratohyal.

The ceratohyal is a long flat bone, broader at the posterior end. Four anterior branchiostegals are attached to this bone. In the Scombridæ and *Cybium*, the dorsal surface of the ceratohyal is nearly straight, while in the other scombroid fishes it is concave.

In the Scombridæ the anterior margin of the ceratohyal is nearly straight; but in the other scombroid fishes this bone has a long process from the anterior lower margin. The ceratohyal is united with the epihyal by means of many fine teeth from both bones, and also the cartilage lying between them. The teeth are larger and more numerous on the inner side. On the external side and near the upper margin there is a narrow groove to receive blood-vessels. In the Cybiidæ the ceratohyal unites with the epihyal by means of long teeth on both the inner and outer sides, except in *Sarda* and *Gymnosarda*. In the latter genera the outer teeth are not found. The groove for blood-vessels is distinct, and sometimes a part of the groove is pierced, as in *Cybium niphonium* and *Gymnosarda nuda*. In the Thunnidæ the tooth-like processes for the articulation with the epihyal are found on the inner side only, as in *Sarda* and *Gymnosarda*. At the ventral margin we find two or three projections, which are inconspicuous in the Cybiidæ. The vascular groove is indistinct, but in *Thunnus* and *Parathunnus* a slit is found in the place. In *Neothunnus* a groove or a slit is hardly visible. In the Katsuwonidæ tooth-like processes for articulation are found on both sides. No slit nor groove is found. Tooth-like processes at the ventral margin are rather conspicuous.

The epihyal is a flat, triangular bone united anteriorly by means of long and fine tooth-like processes with the ceratohyal, and posteriorly with a joint to the stylohyal. This bone carries three branchiostegals. The vascular groove near the upper margin is distinct in the Scombridæ and Cybiidæ; but indistinct in the Plecostei. The bone is short and broad in the Plecostei, especially in the Katsuwonidæ.

The interhyal is a small bone, connecting the hyoid arch through an intervening cartilage with the hyomandibular and the symplectic. In the Scombridæ the bone is styliform, more or less flattened below, in the Cybiidæ broad and more or less flattened, in the Thunnidæ flat, nearly triangular with a lamellar extension on the posterior side, and in the Katsuwonidæ flattened, and more or less rectangular in shape.

The urohyal is a median, laterally compressed, elongated bone gradually widening posteriorly. It is joined to the hypohyals at the anterior end, but free at the posterior end, furnishing a surface for the attachment of the muscle of the isthmus or the throat.

The branchiostegals are flat, slender, curved bones, spanning the membraneous fringe at the mouth of the gill-slit. They are seven in number, and are longer, broader, and more curved posteriorly.

Branchial Arches.

The branchial arches support the gill-lamellæ, and are situated below the cranium, enclosed within the hyoid arch. The general aspect of the branchial arches seems to differ only a little in different groups of the scombroid fishes; but if we examine these arches more closely, the difference among the different groups becomes very distinct (fig. F).

The basibranchials (fig. G) consist of three ossicles in a linear series along the median line. The first is joined to the ceratohyals of the hyoid arch by means of a cartilaginous front end. The second is generally shortest, and the third longest. The second has an oblique groove on each side for the attachment of the first branchial arch. The third ossicle has also an oblique groove for the attachment of the second branchial arch near the anterior end. In the Scombridæ the basibranchials are narrow, laterally compressed, and more or less straight. The grooves for the attachment of

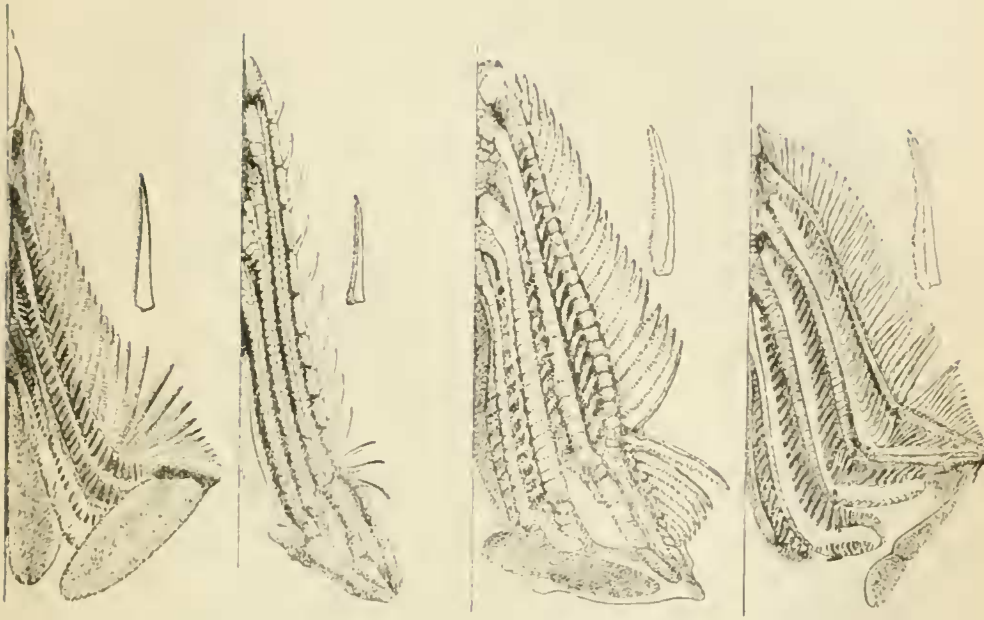


Fig. F. Dorsal view of the branchial arches, and the side view of a detached gill-raker.

branchial arches do not reach the dorsal margin of basibranchials, so that the upper margin of the basibranchials is higher than that of the branchial arches. In *Scomber japonicus* the first basibranchial is nearly so short as the second, and is bent a little downward. In *Rastrelliger chrysozonus* the first basibranchial is the longest, straight at the dorsal margin, while the second and third are short and nearly equal in length. The third ossicle is bent downward at the posterior half. In the Cybiidæ the grooves for the attachment of branchial arches reach the dorsal margin of the basibranchials. The anterior end of the first basibranchial is more or less thickened. The second is bent downward at the middle. In the Thunnidæ the groove for the attachment of branchial arches are very deep and reach the dorsal margin of the basibranchials. The third basibranchial is horizontally flattened. In the Katsuwonidæ the basibranchials are laterally compressed and narrow. The anterior half of the first basibranchial ascends, and the third is bent downward near the posterior end.

The branchial arches are armed with villous teeth, densely growing on

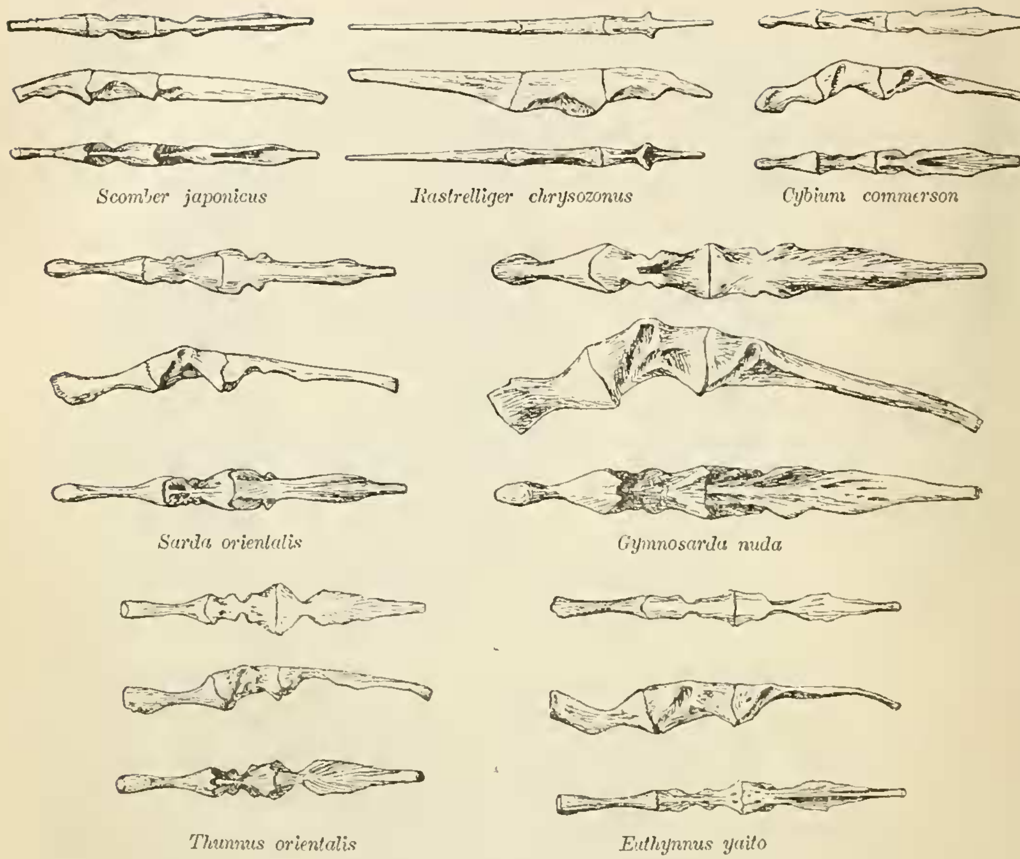


Fig. G. Dorsal, lateral, and ventral views of the basibranchials.

small calcareous pieces on these arches. In the Scombridæ the upper, anterior part of the basibranchial ridge is almost naked, being protected with a few calcareous dentigerous pieces. The villous teeth on the pharyngeal bones are nearly equal to those on the branchial arches, contrasting to the coarser teeth on the former in the other scombroid fishes. In the Cybiidæ dentigerous pieces are arranged in two rows, meeting at the dorsal median line of the branchial arch. In the Plecostei two rows of dentigerous pieces meet near the internal corner of the branchial arch.

The hypobranchials are short, joined to the sides of the second and third basibranchials, and are grooved on the outer or ventral side. They are not found in the fourth arch.

The ceratobranchials are very long, subequal in length, more or less curved upward, and grooved on the ventral side. They are narrow in the Scombridæ, and narrow and compressed in the Cybiidæ, especially in *Acanthocybium*. In the Thunnidæ they are more or less compressed at the anterior portion, but rather flattened at the posterior. In the Katsuwonidæ they are more flattened.

The epibranchials are short, much curved, and often twisted. They are rather elongated in the Cybiidæ. The curving and twisting of these ossicles are remarkable in the Scombridæ; but they are rather elongated in the Cybiidæ.

The upper and lower pharyngeals are broad in the Scombridæ, but in the other scombroid fishes they are narrow.

Pectoral Girdle.

The pectoral girdle consists of a series of membrane bones, connected with the skull at the upper part, forming the anterior border of the abdominal cavity, and at the same time supporting the pectoral fin, it receives the hypaxial portion of the lateral muscle from the cephalic region and some succeeding anterior myotomes.

The post-temporal is a small forked bone. The dorsal branch is flattened and rests on the epiotic, while the ventral branch is articulated to a median knob of the opisthotic. The ventral branch is round or oblong in cross-section and hollow at the anterior end. The branch is produced to a short process posteriorly. In the Scombridae we find a long free bifid process between the dorsal and ventral branches and exterior to the dorsal branch.

In *Acanthocybium* a similar forked auxiliary process is found, partly attached to the exterior side of the dorsal branch. In the other forms of the Cybiidæ, the auxiliary process is not found, and the cross-section of the ventral branch is oblong. The dorsal and ventral processes are connected at their root with a thin lamella. The posterior lamellar portion of the bone is produced forward very little. The interior ridge, continuous to the ventral branch ends with a free point in the genus *Sarda*.

In the Plecostei the post-temporal is well developed, and the interior ridge continuous to the ventral process ends with a free process. In the Thunnidæ the ventral branch is thick and rounded in cross-section. The lamellar portion has the front margin nearly vertical. In the Katsuwonidæ the lower anterior corner of the lamellar portion is well produced, except in the genus *Euthynnus*.

The supraclavicle is a small elliptical bone, more or less pointed at the anterior end, and thickened at the lower margin. At the anterior part this bone fits between the posterior process and the lamellar portion of the post-temporal. The principal part of the supraclavicle rests on the dorsal extended part of the clavicle. On the inner side of the neck of the supraclavicle a strong ligament, which I shall call the clavicular ligament, is inserted with a broad attachment. The ligament connects the axial skeleton with the pectoral girdle. In the Scombridæ the anterior neck and the exterior vascular groove are not conspicuous; but the inner ventral ridge is well developed. In the Cybiidæ the neck is not distinct, except in *Sarda*, neither is the inner ventral ridge well developed. The vascular groove is faint and found in the anterior median part. In the Thunnidæ the neck and the inner ventral ridge are very conspicuous. The shallow, vascular groove is found at the posterior lower margin. In the Katsuwonidæ the bone is nearly the same as in the preceding family; the vascular groove is deep and conspicuous. In *Euthynnus* and *Auxis*, moreover, a large tendon is inserted just behind the attachment of the clavicular ligament. The tendon is the terminus of a hypaxial small cone of some anterior myotomes, about five in number. Thus the supraclavicle is connected to the axial skeleton with a strong straight, transverse ligament, and indirectly with a hypaxial, longitudinal tendon.

The clavicle is a large curved bone, broad at the dorsal end, thin and pointed at the ventral end. The main stem consists of two wings, the exterior and interior, which meet at the anterior margin. At the dorsal anterior corner there is a pointed process. In the Scombridæ the exterior wing is nearly vertical to the interior wing at the anterior part, and the lower anterior extremity is turned more or less externally. In the Cybiidæ the exterior wing is wide, and is bent backward with an acute angle, and the posterior margin of the exterior wing is parallel to the interior wing. The anterior margin of the bone is mostly rounded. In the Thunnidæ the exterior and interior wings meet in an angle approaching a right angle, and the exterior wing is not well developed at the lower half. The exterior wing is produced interiorly beyond the anterior margin of the bone, at the dorsal part, with the same inclination. In the

Katsuwonidæ the exterior wing is nearly vertical to the interior wing, and there is a groove along the external margin of the exterior wing.

Between the pointed process and the posterior lameller part of the dorsal end of the clavicle there is a narrow slit, through which the transverse clavicular ligament, binding the axial skeleton with the supraclavicle passes. The posterior margin of the pointed process is rounded and smooth. To the clavicular ligament, a small ligament joins running along the anterior margin of the broad dorsal end of the clavicle.

The hypercoracoid is a small flat bone articulated to the clavicle at the upper, interior side, and has a round foramen near the centre of the bone. The hypocoracoid is united to the hypercoracoid above and also to the clavicle at the dorsal anterior corner. In the Scombridæ this bone has an external longitudinal keel, and the lower styliform process is long and narrow. In the Cybiidae the bone is broad and has a median longitudinal groove, or rather the bone is bent externally along the longitudinal axis. The lower process is rather broad. In *Cybium* and *Sarda* the central foramen is very small, but it is large in *Acanthocybium* and *Gymnosarda*. In the Plecostei the lower process is broad, uniformly thin, and folded more deeply than in the Cybiidae. Four actinosts basalia or brachial ossicles are found upon the hypercoracoid and hypocoracoid to support the pectoral fin. They become larger as they approach posteriorly. In the Scombridae there is no foramen between the last ossicle and the dorsal posterior process of the hypercoracoid; but in all the other scombroid fishes we find a foramen there.

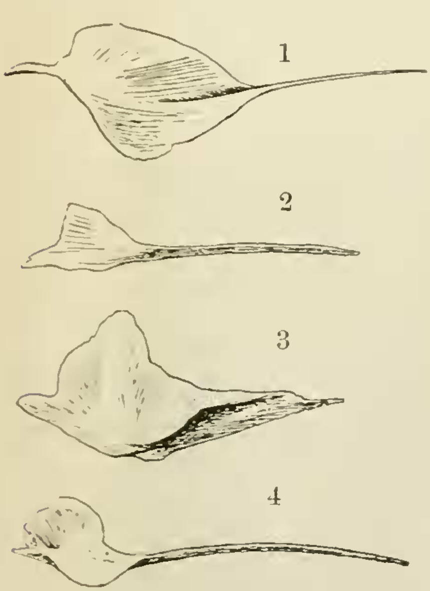


Fig. H. External view of the left lower piece of the postclavicle.

1, *Scomber japonicus*; 2, *Cybium niphonium*
3, *Thunnus orientalis*; 4, *Katsuwonus pelamis.*

The postclavicle is composed of two pieces of bones, and protects the dorsal posterior base of the pectoral fin. The upper anterior piece is lamellar, more or less kidney-shaped in outline, and is bent near the ventral posterior end. Its ventral margin concave, and the dorsal convex. The lower posterior piece is rather broad and lamellar at the anterior part, generally with an ascending pointed process, and a long styliform process behind. This lower piece (fig. H) has more characteristics in different forms of fishes than the upper. In the Scombridae the lamelliform portion is comparatively large, and the styliform process suddenly narrows and bends upward. In the Cybiidae the styliform process is rather broad and straight, while the lamelliform portion is rather small and flattened. In the Plecostei the lamelliform portion makes an angle with the styliform. In the Thunnidae the angle or the bent portion is raised and thick, and the styliform portion very short. In the Katsuwonidae the styliform portion seems as if joined to the lamelliform portion, at the inner side near the ventral margin. The styliform portion is long.

Pelvic Girdle.

The so-called pelvic girdle is a pair of bones united at the median line, imbedded free in the ventral part of the abdominal wall. Each bone consists of three parts:—anterior, external portion; anterior, internal portion; and posterior styliform portion. The first named portion is largest, and serves for the attachment of muscles. The last two portions meet, with roughened surfaces, their fellows of the other side. The portion of the pelvic girdle where the ventral fins articulate is thick and transverse. The anterior external portion is most well developed and most complicated. In the posterior half of the portion we distinguish three wings;—external, internal, and ventral.

In the Scombridae the pelvic girdle is quite small. The anterior external portion is elongated and bent upward, with its external and internal wings meeting in one plane. The ventral wing is short and small. The anterior internal portion is thin, slender, and has nearly the same length as the ventral wing. The posterior styliform process is also very short. In the Cybiidae the anterior external portion is long and straight, more or less vertical at the anterior part, and the cross-section of the posterior part is triradiate. The anterior internal portion is short and slender, about one-third of the external

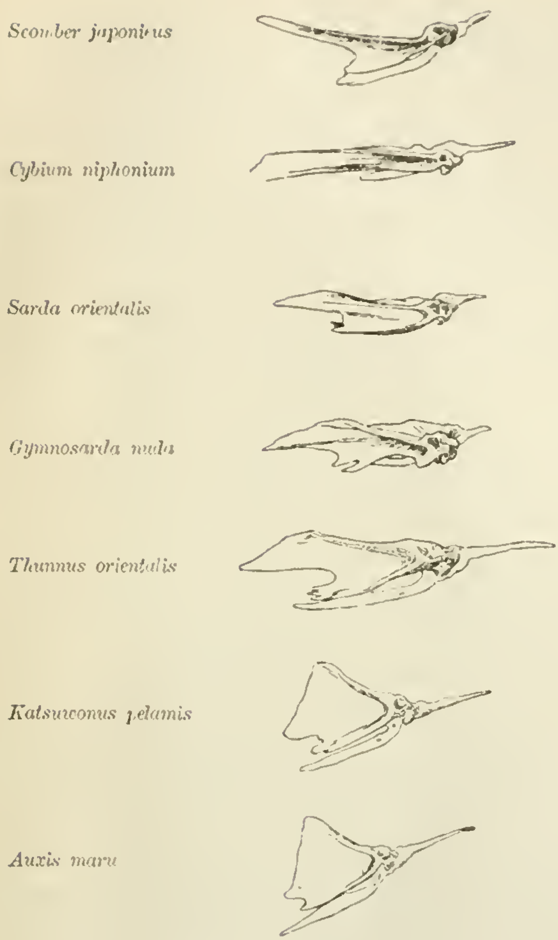


Fig. I. Left external view of the pelvic girdle.

portion in length. The posterior styliform process is rather short. In *Gymnosarda* the external wing of the anterior external portion is turned obliquely towards the external, ventral side, and is not thickened nor folded at the external margin. In the Thunnidae the pelvic girdle is very strongly developed. The anterior external portion is broad, rather thick, and the dorsal exterior margin is also thick and folded. In this family the external and ventral wings of the anterior external portion are nearly in one plane, and the internal wing is united to the middle of the plane, formed by the other two wings. The external wing is folded at the external margin. The anterior internal portion is a little longer than the ventral wing of the anterior external portion. In the Katsuwonidae the pelvic girdle is more specialized. The anterior external portion is thin, and fan-shaped, with a thick external margin. The anterior internal portion is more or less longer than the outer, especially in *Euthynnus* and *Auxis*. The styliform process is very long and laterally compressed. Fin-rays are directly articulated to the thick portion where the three different portions of the arch meet.

Vertebral Column.

The general feature of the vertebral column of the different types of the scombroid fishes may easily be understood by examining Plate XIV, showing the middle transverse section of vertebrae.

In the Scombridae (fig. 30) the number of vertebrae is not large, being 31 in total, and the number of the precaudal vertebrae is nearly the same as that of the caudal. The vertebrae are small, longer than broad, nearly equal in size and form, and are articulated with each other rather loosely by means of short, small zygapophyses. In *Scomber japonicus*, however, the anterior zygapophyses, both superior and inferior, are very broad in the caudal vertebrae, and their anterior margin is divided. The articulating surfaces of the first vertebra with the skull are two, separate, and turned axially, just opposite to the ordinary case. Thus a pair of stout processes at the dorsal corner of the first vertebra grasps the posterior end of the basioccipital (fig. 30, C). The neural spine is nearly equally slender, throughout the whole length of the vertebral column, and the first spine is never free. The anterior concavity of the vertebra is a little shallower than the posterior. The neural and haemal spines are nearly straight, oblique, and generally they are compressed anteroposteriorly. The parapophyses are not developed, and the haemal spine is scarcely developed in the precaudal region. Almost all the precaudal vertebrae have their neural canal divided into two. The lower canal is for the spinal cord, it is entirely covered by a bony roof, separated from the upper canal for the dorsal ligament. The lateral transverse ridge in the anterior precaudal vertebrae is quite peculiar to this family (fig. 7). The last vertebra is not fused with the hypural bones.

In the Cybiidae the total number of vertebrae is very variable, generally over forty. The least number of them in my collection is thirty one in the genus *Grammatorcynus*, and the maximum number sixty four in *Acanthocybium solandri*. The relative number of the precaudal and caudal vertebrae also varies. Generally the precaudal vertebrae are less in number than the caudal. In *Acanthocybium solandri* and *Sarda orientalis*, however, the precaudal vertebrae are more numerous, while in *Sarda chilensis* and *Gymnosards nuda* the number of vertebrae in both regions is exactly the same. Vertebrae are generally very short, disk-like near both extremities of the body (fig. 41). In most vertebrae six longitudinal grooves are found;—dorsal median, ventral median, and two pairs of lateral grooves (figs. 8–12). The vertebral column of *Acanthocybium solandri* (figs. 10, 39) and *Cybium koreanum* is different from that of the other forms in having three lateral grooves instead of two. The first neural spine is not always fused to the centrum, nor forms a complete ring at the proximal part, for the spinal cord. In the genus *Sarda*, however, the detachable neural spine of the first vertebra forms a complete ring, being fused at the lower end. Some anterior neural spines are broad and strong. The other neural and haemal spines are slender and weak, and in the middle of the body they unite to the centrum of vertebrae almost perpendicularly at least at their insertion (figs. 39, 41, 42), except in *Cybium chinense* (fig. 40). They are not compressed laterally. The last vertebra is coalesced with the hypural bones and forms a lozenge shaped bone, with a small median notch at the posterior margin. Transverse processes are not developed, but haemal processes and haemal spines of some length are found in many precaudal vertebrae (fig. 38–42). Some of these spines are turned anteriorly in *Cybium niphonium* and *Gymnosarda nuda*. The hypural process of the last haemal spine is notably prominent, and the vertebrae in the caudal peduncle are remarkably small, gradually narrowing backwards, except in the genera *Sarda* and *Gymnosarda*. In these genera the hypural process of the last haemal spine is narrow and the vertebrae of the caudal peduncle are not modified in size, but in form, becoming quadrate prismatic, with their neural and haemal spines broad and flat, as we find in the Plecostei. These spines project backward nearly horizontally, and firmly lay hold of the succeeding vertebra. In these vertebrae the lateral ridges are remarkably developed to the lateral keels (figs. 11, 12). In these cases the two vertebrae preceding the last vertebra are small and flattened anteroposteriorly and are capable of lateral movement. The inferior foramen is developed in some caudal vertebrae; but generally it is small and inconspicuous, especially in the genus *Cybium*. In the superior zygapophyses both the anterior and posterior pairs are large. In the Scombridae and Cybiidae the haemal canal of precaudal vertebrae is suddenly reduced in calibre in some anterior vertebrae. This is due to the exclusion of the cardinal vein from the haemal canal.

In the Plecostei the total number of vertebrae is thirty nine, except in the genus *Katsuwonus*, which has forty-one vertebrae. The vertebrae are articulated together so firmly that the vertebral column allows little motion to either side. The free lateral motion of the vertebral column is possible only at the root of the caudal fin, where two vertebrae (the last but one and its antecedent) are remarkably thin, and their neural and haemal spines are long, diverging, and flattened at the root. Generally the number of the precaudal vertebrae is nearly equal to that of the caudal. The vertebrae are 18+21 in the Thunnidae, 20+21 in the genus *Katsuwonus*, and in the other genera of the Katsuwonidae 20+19. The relative number of the precaudal and caudal vertebrae is often mistaken, as the haemal spine is also very well developed in the precaudal vertebrae. Moreover, it is remarkable that the haemal spine of some anterior precaudal vertebrae is turned forward in the Thunnidae (figs. 49-52, 64). In *Auxis* the epihaemal spine is also turned forward in the caudal region too. Thus *Katsuwonus* has the same number of caudal vertebrae as the Thunnidae, and the number of the precaudal vertebrae does not differ from that of the other genera of the Katsuwonidae. In GÜNTHER's catalogue less numbers of vertebrae are recorded; but this I am inclined to believe to be erroneous. Vertebrae differ greatly in shape and structure in the different parts of the body. They are much modified near both extremities of the body; but they are comparatively simple and light at the middle. It is noteworthy that the haemal spine is very well developed in some precaudal vertebrae too, so that when ribs are detached it is rather difficult to distinguish them from caudal vertebrae. However the haemal spine of the precaudal vertebrae is broad, thin and laterally compressed at the distal end, for the attachment of ribs, and it is of course shorter than that of the anterior caudal vertebrae. It must be noticed also that the haemal spine of some anterior precaudal vertebrae is turned forward (figs. 49-52). Each vertebra has a pair of short pointed lateral apophyses at the anterior margin of the insertion of the intermuscular bone, especially well developed in the caudal vertebrae. These apophyses serve to keep the intermusculars fast to the vertebrae. The four pairs of zygapophyses are well developed, of which the superior prezygapophyses are best developed. In the Thunnidae the transverse process is well developed in some precaudal vertebrae (figs. 13, 49-52, 64). On the dorsal surface of these transverse processes, the head of the intermuscular bones and ribs are inserted close together, the former preceding the latter. The haemal canal is narrow in *Thunnus* and *Parathunnus*;

but in *Neothunnus* it is nearly equal to or broader than the diameter of the vertebral column, and it is still wider in *Katsuwonus* and *Euthynnus* (figs. 57, g; 58, g). In the Katsuwonidae the canal is separated from the vertebral column by the development of a peculiar median process which I propose to name as the epihaemal process. These processes as well as the neural, and haemal processes are more or less laterally compressed. The neural and haemal processes are greatly bent backward near the distal end in vertebrae of the middle part of the vertebral column. In *Auxis* the haemal canal is not closed in the precaudal region. In *Thunnus* and *Parathunnus* the haemal canal is closed in the 10th vertebra; but in *Neothunnus* in the 11th. In the Katsuwonidae the canal is closed still further back:—In *Katsuwonus* 12th, in *Euthynnus* 16th, and in *Auxis* 21st.

In the Thunnidae the first vertebra is very short, and is always anchylosed to the occipital region with a zigzag suture, so firmly that many authors overlooked its centrum, though they found the detachable neural arch belonging to it. The anterior margin of the first neural spine is not straight, but notched. In the vertebrae of the Thunnidae the longitudinal grooves are conspicuous, especially the lateral grooves. The vertebrae are massive, and are finely striated at the surface, and the internal part is alveolar. The inferior foramen as well as the haemal canal are very poorly developed in *Thunnus* and *Parathunnus*; but in *Neothunnus* they are well developed in caudal vertebrae. In this family the transverse process is developed from the fourth vertebra. It is well developed in the following three to five vertebrae, as a short, nearly flat process with a more or less trenchant edge. In the Katsuwonidae the first vertebra differs but little in size from the following vertebrae, and is less firmly anchylosed to the skull, and at the same time the relation between its centrum and the neural process is much closer, not easily separating from each other. The lateral grooves of the vertebrae communicate with each other near the axis in anterior vertebrae of the precaudal region, and in *Euthynnus* and *Auxis* (fig. 15) the ridges between these grooves are poorly developed or disappearing, thus the vertebral column is much more slender than in the tunnies. The mass of the vertebrae is greatly diminished, as the interior alveolar part is nearly lost, leaving the hard, compact, cortical layer only. The surface of the vertebrae is nearly smooth. The inferior foramen is enormously developed, and is found in the precaudal region as well in *Katsuwonus* and *Euthynnus* (figs. 57, 58); but in *Auxis* the foramen is found poorly developed and in a few posterior caudal vertebrae only. In this family a pair of special protuberances appear in a few anterior vertebrae. These protuberances lie just behind the superior zygapophyses, and they serve to furnish points of attachment to a pair of strong tendons of the lateral muscle.

In the Plecostei the neural and haemal spines and other processes from vertebrae for the mutual articulation are well developed. The neural spine of certain anterior vertebrae is broad and rough for the insertion of muscles, and in bonitos the neural arch of these vertebrae is perforated with numerous pores of different sizes. The other neural spines are long, slender, laterally compressed, and nearly vertical to the vertebral column at their origin. The haemal spine is remarkably well developed in the precaudal region in tunnies; but in bonitos the spine is scarcely developed in this region. However a median spine of quite new origin makes its appearance in the Katsuwonidae. It was first described by STARKS (69) under the name of pedicle; but I propose to name it the epihaemal process. The spine is developed between the centrum and the haemal process or the haemal arch, and is best developed in the posterior part of the precaudal region. The anterior superior zygapophyses of anterior precaudal vertebrae are long, more or less bent inward at the lower margin in the Thunnidae; but they are more or less triangular pyramidal in the Katsuwonidae, and there is an accessory zygapophyses as in the Scombridae. The anterosuperior zygapophyses in the posterior portion of the vertebral column are elongated and flat, both in the Thunnidae and Katsuwonidae; but in the latter family the accessory zygapophyses are formed beneath the ordinary zygapophyses to clasp the posterior superior zygapophyses between these two zygapophyses. In the Thunnidae the inferior zygapophyses are short and pointed at the end, more or less diverging from the middle of a vertebra, and they do not come into close contact with those of the next vertebra, as in the Cybiidae. In the Katsuwonidae, however, the inferior zygapophyses of a vertebra are long and in close contact with those of the next vertebrae.

Ribs and Intermuscular Bones.

The ribs are developed along the internal anterior margin of the precaudal myotomes, on both sides of the abdominal cavity, running obliquely backward, to a point where the myotome turns to bend anteriorly. Hence the length and the direction of ribs are determined by the internal boundary lines of the upper portion of the hypaxial half of the lateral muscle. Generally the rib is developed from the third vertebra and is united either directly to the centrum or to the transverse process, or to the distal end of the haemal process or the precaudal haemal spine. Ribs near both extremities of the abdominal cavity are short; but the other ones are nearly the same in length. They are broad, and form the roof of the abdominal cavity, especially those at the anterior half of the series.

In the Scombridae the ribs are slender, roundish in cross-section, nearly the same in shape and length, separated from each other, and reach quite near the ventral median line (fig. 1). The intermuscular bones form a series of slender bones between the epaxial and hypaxial portions of the lateral muscle, and along the anterior surface of the myotome. They are well developed, slightly curved in anterior precaudal vertebrae, their tips reaching the external surface of the lateral muscle, and are bent backward below the skin. The intermusculars are developed from the first vertebra to about the twentieth in *Scomber japonicus*. In the latter species the intermuscular bones are inserted just at the base of the haemal arch or process, and seven or eight anterior ones are long enough to appear on the surface of the lateral muscle. The tips of these long intermuscular bones do not overlap each other, and they are at a little distance above the lateral median line of the body (fig. 1). In the other scombroid fishes tips of the intermuscular bones appear at the lateral median line.

In the Cybiidae the ribs are generally slender, subequal, and lie close to, but do not touch each other. In *Acanthocybium solandri* and *Sarda orientalis* some ribs are very broad. Intermuscular bones are found between some cephalic myotomes too, and sometimes we find two pairs in the region, both on the exoccipitals. In the genus *Acanthocybium* the intermuscular bones except the first are attached to the head of ribs, as was observed by Starks, not on the centrum as in the other scombroid fishes, and in this genus only the first rib is found on the second vertebra, instead of the third. In this family the tips of long anterior intermuscular bones overlap each other at the external surface of the lateral muscle. In *Cybium* the intermusclar bones are scarcely developed in the caudal region (fig. 6), and the anterior intermuscular bones are turned more or less upward. In other scombroid fishes the intermuscular bones almost lie in one plane. In *Sarda* intermuscular bones are very well developed. They are thick and long in the anterior precaudal region. In *Acanthocybium solandri* the intermuscular bones are ten in number, and are found in the precaudal region only; but in *Sarda* and *Gymnosarda* they are found in the caudal part too.

In the Plecostei the ribs are broad, dorsoventrally compressed, and gradually attenuated towards the posterior, internal side. They lie close to each other and do not hang down along the peritoneum, but they thatch the roof of the abdominal cavity. In the Thunnidae the proximal portion of one or two ribs, lying just before and above the root of the cutaneous artery, is very slender, so as not to obstruct the free passage of the blood. In a large specimen of *Thunnus orientalis* I found that the fifth and sixth ribs consist of two parts. The short, slender, proximal part lies at the anterior slope of the hypaxial portion of the lateral muscle, which is rather suddenly developed from the myotome of the seventh vertebra. These are probably abnormal. The intermuscular bones are developed from the cephalic region to the caudal region, and they are united to the lateral median line of the vertebral column, and each pair at the anterior margin of the centrum of each vertebra, except in the first vertebra, in which these bones are attached to the neural arch. These bones are long, slender, and their distal ends lie at the external surface of the lateral muscle in the anterior part of the body (figs. 2–5); but the majority of them have their distal end at the boundary between the superficial dark red muscle and the profound dark red muscle. The intermuscular bones found anterior to the seventh vertebra are long, and appear on the surface of the lateral muscle, while those posterior to the seventh vertebra become short rather suddenly, and in the case of Katsuwonidae the last two to seven of those intermuscular bones are divided into two portions (fig. 5); the part beyond the profound dark muscle is separate from the proximal part and these two parts are connected with a ligament. Intermuscular bones on the third and fourth vertebrae are fused to the dorsal side of the head of the respective ribs, and united to those vertebrae. In the Thunnidae the ends of some posterior ribs lie close on both sides of the thick group of interspinous bones of the anal, and in these the posterior pairs of one side run quite near their fellows of the other side.

Interspinous Bones.

In the skeleton of the median fins of the scombroid fishes, we distinguish three types :—(1) that of the first dorsal, (2) that of the second dorsal and anal, and (3) that of the dorsal and anal finlets. Each interspinous bone consists of the distal and proximal segments, and the latter segment is furnished with lateral and sagittal wings. The first interneural is the longest.

In the first dorsal, spines articulate with the proximal segment, behind the wide, dorsally bent distal segment. The posterior end of the proximal segment is also wide and dorsally bent, behind the point of articulation of the dorsal spine. The exterior margin of these dorsally bent parts is often serrated. These dorsally bent parts form the wall of the groove for the first dorsal fin.

In the second dorsal and anal, the interspinous bones are anteroposteriorly compressed, and the divided proximal end of spines or rays grasps the distal segment, and articulates with the proximal segment.

In the region of the finlets, the interspinous bones are elongated anteroposteriorly, often with the development of the middle segment. The distal segment is very small, and is grasped by the proximal ends of fin-rays, and articulates with the proximal segment.

Interspinous bones of the first dorsal and finlets are generally found one of each in each myotome, but those of the second dorsal and anal are generally two in each myotome. No spurious interspinous bones before the first dorsal. The interspinous bone of the last finlet of the dorsal and anal wants the proximal segment, and is attached to the posterior end of the proximal segment of the preceding finlet.

In the Scombridae the interspinous bones are weak and narrow, and there are some spurious bones between the two dorsals, one in every myotome, and the free lower end of the interspinous bones of the first dorsal are inserted between the tip of the neural spine of precaudal vertebrae. The anterior interspinous bones are inserted more than posterior ones. In *Restrelliger* the interspinous bones carrying finlets have their sagittal wings well developed.

In the Cybiidae the lateral wings of the first dorsal interspinous bone gradually narrow towards the dorsal end. The distal segment of the first dorsal interspinous bone is a very small round ossicle. Anterior interspinous bones are oblique, but those behind the middle of the vertebral column are more or less vertical.

In the Plecostei (fig. 44) the first dorsal interspinous bone is very well developed with the lateral wings turned anteriorly, and the anterior sagittal wing is very broad, but the lower part not developed, terminating at the middle of the lateral wings at the axis. The distal segment in the first dorsal is broad and turned over upward, and the dorsal posterior end of the proximal segment is also expanded laterally, except a few anterior interspinous bones. These expanded parts are turned up, quite like the distal segments. Some posterior interspinous bones of the first dorsal are laterally compressed and want the lateral wings. In the second dorsal proper the interspinous bones are compressed anteroposteriorly and two of them are generally found in every myotome, instead of one in the first dorsal. In the Carangidae two or three interspinous bones are found in one myotome under the first dorsal. In each interspinous bone the lateral wings are better developed than the sagittal wings. In the second dorsal the distal segment is a small narrow bone, inserted between the bases of the two moieties of each fin-ray. The exterior margin of the lateral wings is strengthened by the development of accessory ridges. The interspinous bones of the anal fin differ more or less from those of the second dorsal, and resemble rather the first dorsal. The first ventral interspinous bone is longer than the succeeding bones, and some anterior ones are fused together. Most of them have wide lateral wings but the sagittal wings are not well developed. The lateral wings increase in width towards the free end, and suddenly converge toward the pointed extremity. Two of these interspinous bones are found in every myotome. Interspinous bones of the finlets are quite alike in the dorsal and anal. They are more or less rod-like in the Thunnidae; but they have lateral as well as sagittal wings in the Katsuwonidae, and in the posterior part the sagittal wings only are developed. The distal segment of the interspinous bones of the second dorsal and anal is very small, and is inserted between the two moieties of the fin-ray.

The lateral margin of the distal segments and that of the dorsal posterior end of the proximal segment are mostly serrated in the Thunnidae, but is straight and entire in the Katsuwonidae.

MUSCULAR SYSTEM.

I have chiefly examined the lateral muscle, the other muscles were scarcely touched. The great lateral muscle is originally composed of as many transverse segments as there are vertebrae, and each segment is attached internally to the respective vertebra and its processes and appendages,—neural and haemal processes, ribs, and intermuscular bones. The first three muscle-segments, however, do not correspond to the first three vertebrae, as these three segments belong to the cephalic, or rather occipital region, where we find one or two auxiliary intermuscular bones between them, in the Cybiidae and Plecostei. These cephalic myotomes are inserted between the foramen magnum and the pterotic processes of the cranium, and connects the skull with the pectoral girdle. Hence the fourth muscle-segment or myotome corresponds to the body-segment of the first vertebra. Moreover, some myotomes seem sometimes to augment by subdivision, in fishes of the Katsuwonidae. In *Auxis* one or two auxiliary myotomes are added in the hypaxial half. Generally one auxiliary myotome is added near the boundary between the precaudal and caudal portions. When there is another auxiliary myotome, it is found in the anterior part of the precaudal region, where the cutaneous artery appears to the surface of the body. These auxiliary myotomes are not always bilaterally symmetrical. Moreover two auxiliary myotomes are sometimes found in one side, and only one in the other. At the caudal region some myotomes are coalesced and they are much elongated anteriorly. The myotomes in the caudal peduncle are united into one in the Plecostei, in the region where the lateral keel makes its appearence in the vertebrae, and where the neural and haemal processes are broad and horizontal. Thus in the anterior part of the adult fish, the number of myotomes is greater than that of the vertebrae, and in the caudal region the number is reduced from the confluence. The cephalic myotomes as well as some following myotomes project anteriorly as a triangular mass, and their thin, dorsal limb is bent forwards along the dorsal median line over the cranium. In the Plecostei each myotome faithfully follows the course of the neural and haemal processes to their ends, at the median longitudinal plane, not separating from them on the way, as is found in some teleostean fishes. Each myotome is bent in a zigzag line on the surface of the body, and may be separated into four parts, right, left, dorsal or epaxial, and ventral or hypaxial. The two lateral halves of the myotome are well separated by a thick membrane, aponeurosis, spun on the axial skeleton and its processes, and by the abdominal cavity. The membrane is very thick in the Plecostei. The dorsal and ventral portions are separated by a membrane of connective-tissue, connecting intermuscular bones, tendons, and ligaments.

In the Teleostei muscle-fibres are generally well discernible from outside even in the last myotome (except in the genus *Sarda*); but in the Plecostei many caudal myotomes are changed to tendons at the posterior, external surface (fig, 3). Therefore the extremity of the caudal portion looks bluish, when the skin is removed. In the Plec stei nearly eight last myotomes seem to be fused into one. In *Auxis* the tendon of the last myotome is enormously elongated anteriorly, reaching far beyond the anus, to about the middle of the 17th myotome (fig. 2).

The muscular system, as may be supposed from other structures, is well developed and much complicated in the Plecostei and allied fishes. The course of the myotome runs at its external surface from the dorsal median line sharply backward, then gently forward, and gently a little backward to the lateral median line; in the ventral half slightly forward, then, gently backward, and lastly sharply forward (fig. 3). The backward bend at the lateral median line is noteworthy in these fishes, in more primitive fishes the bend is not found at all. The bend is sharper in the anterior portion than in the posterior portion of the body. Indeed the zigzag course at the surface becomes more sharply bent as the position of the fish advances higher, and at the same time the conical forward outgrowth of the myotome is more elongated. The epaxial conical outgrowth is longer than the hypaxial, and is much more reduced in thickness. Therefore we find many concentric circles of myotomes in the cross-section of the lateral muscle, 3 or 4 in the Scombridae, about 10 in the Cybiidae, and 10–16 in the Plecostei (figs. 16–19). The backward bend of myotomes in the epaxial and hypaxial portions has some breadth in the Scombridae and Cybiidae (fig. 6), therefore we find two parallel traces of connective-tissue fibres, which connect firmly with the vertical aponeurosis, ensheathing the axial skeleton from both sides of it, just at the end of the neural and hæmal processes, where the myotomes are very sharply bent. In the Plecostei, however, myotomes are very thin at the points of external bending and they are inserted to the axial skeleton at one line of traces. In *Cybium* the number of cones of myotomes in cross-section of the lateral muscle is only a little more numerous than in *Scomber*, but in *Sarda* the number is almost as many as in the Thunnidae. At the anterior end of the body the apex of the cones is nearer the axis than to the surface of the body; but in the caudal portion it gradually approaches the surface. In the Katsuwonidae (fig. 19) a part of some anterior myotomes envelopes a large tendinous chord from the second vertebra, or rather a part of some anterior myotomes forms a small auxiliary cone of concentric myotomes, which ends in a strong tendon attached to the second vertebra. In *Euthynnus* and *Auxis* another smaller auxiliary cone of myotomes round a tendon is inserted into the supraclavicle (fig. 2).

In the Scombridae and Cybiidae and also in the Katsuwonidae the dorsal and ventral limbs of the myotome are more or less wide at the insertion into the median septum; but in the Thunnidae the dorsal and ventral limbs of the myotome are very thin.

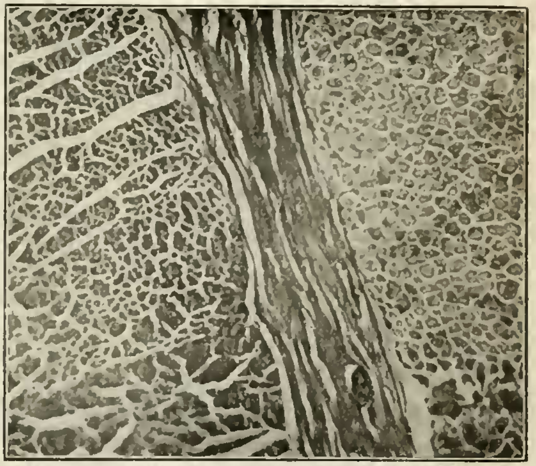
The dorsal limb of some anterior myotomes always reaches the front margin of the frontals in the Plecostei, but in the Teleostei it is not always the case.

In fishes the median superficial lateral muscle is generally darker in colour. Its extent is sometimes very well defined, but sometimes more or less indistinct. It is thin and narrow at the anterior part, but thick and wide at the posterior. This dark coloured portion is triangular in cross-section, and is bounded by membranes of connective tissue, which are united to the line connecting the distal end of intermuscular bones. In the Teleostei tendons of the great lateral muscle are mostly found in the superficial dark coloured portion; but in the Plecostei they are found in deeply seated dark coloured muscles. The deeply seated dark red portion of the lateral muscle is characteristic to the Plecostei. It is called "chiai" or "chimi" in our country, from very old times. In 1712 RYONAN TERAJIMA described "chiai" as being found in two bands in bonitos and tunnies, and being inferior in taste to the ordinary muscles. In the Plecostei the ordinary flesh is remarkably reddish, as the special superficial segmentary canals send a copious flow of blood into it (fig. 3). The dark colour of the median superficial muscle is due to the rich supply of blood from segmentary arteries along the intermuscular bones. The darker colour of the "chiai" portion is also due to the same cause, but from a different source.

In the Plecostei as the ordinary muscles are red coloured, the median superficial muscle as well as the deeply seated portion round the axial skeleton are nearly blackish red as they receive more blood than the ordinary muscle. The blackish red portion scarcely reaches the centre of the concentric circles in the cross-section of the lateral muscle. In tunnies the blackish red portion does not reach the vertebral column in the epaxial portion, but in the hypaxial portion it always reaches. This is well marked in the posterior portion of the body. The blackish red portion is thin and flat at the anterior part of the body, it then becomes gradually thick, thickest at the posterior part of the precaudal region and then being compressed laterally moves towards the surface together with the centre of the concentric circles in the cross-section. The boundary of the "chiai" portion is quite distinct. In the process of curing, the curer observes that the "chiai" portion is liable to separate from the surrounding portion. In the Katsuwonidae the epaxial portion also reaches the axial skeleton (fig. 19), and the hypaxial portion has a wide base for the insertion to the axial skeleton as the dorsal aorta which supplies blood to the "chiai" portion is more or less separated from the vertebral column by the development of the epihaemal process. In this family the posterior part of the superficial lateral muscle is not so dark as the deeper layer. This is due to the fineness of the cutaneous artery in the posterior part. The shape and volume of the "chiai" portion vary in different species. In the Thunnidae, *Thunnus orientalis* has a comparatively large voluminous dark red portion, but *Neothunnus macropterus* has a small quantity of the dark red portion. In the Katsuwonidae the quantity of dark red portion is comparatively large, especially in *Auxis* which has about one fourth of the lateral muscle dark coloured. In the "chiai" portion tendons are well developed, especially in the epaxial portion and in the caudal portion (fig. 2). In the Teleostei the most active part of the lateral muscle seems to be the median superficial part, while in the Plecostei it seems to be the deeply seated "chiai" portion. In the Teleostei the dark coloured portion gradually becomes broader and thicker in the caudal portion, passing beyond the limit of the median superficial lateral muscle. I have examined and found that the dark red portion contains about 7 times as much blood as the other portion in *Thunnus orientalis*, and about 15 times as much as in *Parathunnus mebachi*. In *Scomber japonicus* the superficial red muscle contains almost 8 times as much blood as the other flesh, and in *Cybium niphonium* the superficial red muscle contains 12–13 times as much blood as the ordinary flesh, which is nearly colourless.

Histologically the dark red portion consists of uniform and fine fascicles, with many capillaries among them, and their mucle-fibres are faintly striated, more or less resembling the involuntary muscle-fibres. When the dried muscle of tunnies or bonitos are broken transversely, the chiai portion is rather rough and not lustrous, while the other portion is quite smooth and conchoidal.

In the Katsuwonidae the chiai portion is better developed than in the Thunnidae, and both the epaxial and hypaxial parts of it reach the vertebral column, as the chiai portion has a wider base than in the tunnies, and as the segmental blood-vessels nourishing the portion originate on each side of the dorsal aorta and its plexus at two points, a little above and more or less below the vertebral column.



Dark red portion *Vascular plexus*

Fig. J. Cross section of the lateral muscle, showing the large fascicles of the ordinary portion on the right side, and fine dark coloured fascicles of the dark red portion on the left.

To the ventral side of the vertebral column a pair of cylindrical muscles are inserted to suspend the pharynx. These muscles run obliquely forwards from the vertebral column. These pharyngeal muscles are inserted into the 3rd and 4th vertebrae in *Scomber japonicus*, to the 4th in *Rastrelliger chrysozonus*, to the 3rd in *Grammatorcynus bilineatus,* to the 6th in *Cybium niphonium,* to the 5th and 6th in *Sarda orientalis,* to the 5th in *Gymnosarda nuda,* to the 5th in *Thunnus germo,* to the 5th and 6th in *Thunnus orientalis* and *Neothunnus macropterus,* and to the 6th in *Parathunnus mebachi* and *Auxis.*

In the Scombridae and Cybiidae weak short slender tendons are developed from the root of each horizontal apophysis obliquely forward along the border of each myotome and are firmly attached to the ventral side of the distal end of the preceding apophysis and intersect with ligaments running along those processes. In the Plecostei these tendons are much better developed, being longer and more obliquely inclined, especially at the anterior and posterior ends of the body. These tendons are split into two sheets of fine fibres at the apex of the intermuscular bones, and the sheets run dorsalward along the axial sides of the superficial dark coloured muscle. These sheets are transformed to the myocommata. The lateral tendons are not found from the middle part of the lateral keel in the caudal portion.

Dr. NORIO OGATA (58) found that the alcoholic extract from the chiai portion of the muscle is valuable as an antigen in WASSERMANN's reaction for syphilis. In the Thunnidae the dorsal anterior end of the stomach is connected with the roof of the body-cavity by means of a short, slender, median muscle.

In the teleostean fishes the quantity of flesh amounts to less than sixty percent of the total weight of the body, but in the Plecostei it is more than seventy percent, especially abundant in *Thunnus germo,* as in this species the dorsal wall of the abdominal cavity is convex. This abundance of flesh is due to the narrowness of the visceral cavity, or the great development of the hypaxial portion of muscle in the precaudal region. Mr. G. YUASA of the Los Angeles Sea Food Packing Co. told me that 1 ton of *Thunnus germo* produces 45 cases of canned meat, while from *Neothunnus macropterus* only 37 cases are produced.

LIGAMENTS AND TENDONS.

As the so-called scombroid fishes are generally active swimmers, they are rich in ligaments and tendons, which are best developed and most complicated in the Plecostei. A well developed ligament generally present in teleostomatous fishes connects the shoulder-girdle with the axial skeleton. I shall distinguish this ligament under the name of the clavicular ligament. It is inserted to the inner side of the supraclavicle at one end, and to the occipital region or to one of the anterior vertebrae at the other. Another ligament, commonly found in the teleostean fishes is long, situated in the spinal canal, above the spinal cord, thus connecting the vertebrae. A short median ligament connecting the skin in the head to the frontals is peculiar to the Thunnidae. A pair of thin and short ligaments is found between the first and second vertebrae in the genus *Auxis*. Besides these there are many ligaments connecting different parts of the skeleton.

Tendons are well developed near both ends of the body, especially near the tail, and in the fishes of the Katuwonidae. A longitudinal tendon running from the tail and forming the axis of a large muscular cone is very long in *Auxis* (fig. 2). In this genus two tendons forming the anterior extremities of the two hypaxial cones of myotomes just below the median septum between the epaxial and hypaxial portions of the lateral muscle are remarkable. The external tendon is attached to the supraclavicle, just behind the attachment of the clavicular ligament, and the internal to the large lateral tubercle of the second vertebra. Between every two body-segments we find a pair of tendons. These tendons connect the intermuscular bones, and are joined at the abaxial end to the myocommata. In the teleostean fishes these tendons are simple, but in the plecostean fishes they are longer and much more complicated, as they make more acute angles with the vertebral column.

NERVOUS SYSTEM AND SENSE ORGANS.

The brain-cavity of the scombroid fishes is small as in other teleostomatous fishes, and the brain does not occupy even the whole of this small cavity, being surrounded by a thick layer of a fatty substance. Thus even a tunny of ca 40 kg has a brain as small as a man's thumb. The brain of the scombroid fishes does not differ much from the common type of the brain of the Teleostomi. The enormous development of the optical lobe and cerebellum is striking. The nondevelopment of the cerebral hemisphere is also remarkable. In the Plecostei the optical lobe has a very large groove on the ventral side, as if the lobe is made by folding, when seen from that side. The groove is especially remarkable in *Auxis*, in which a corresponding groove is found in the ventral side of the skull, in the otic region.

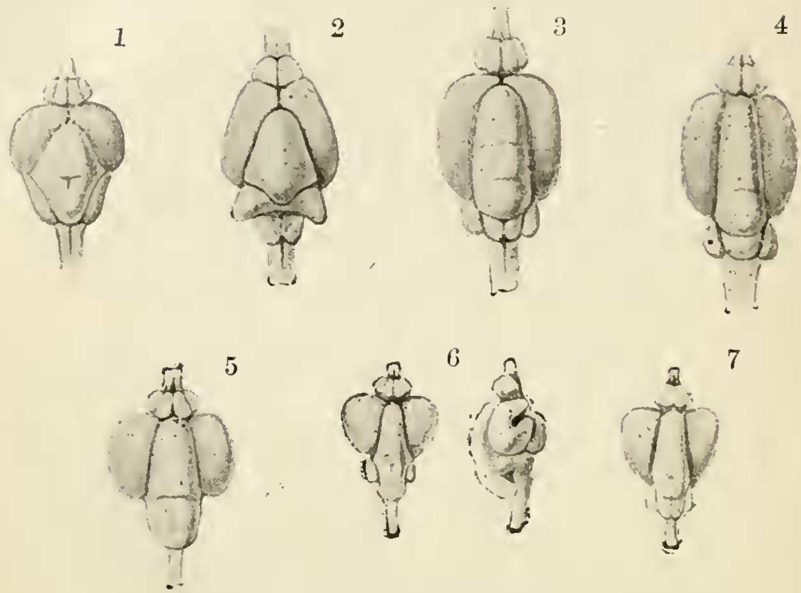


Fig. K. Dorsal view of the brain.

1, *Scomber japonicus*; 2, *Cybium niphonium*; 3, *Thunnus orientalis*; 4, *Thunnus germo*; 5, *Katsuwonus pelamis*; 6, *Auxis maru* (dorsal & lateral); 7, *Euthynnus yaito*.

In the Plecostei the brain is thicker than that of the Teleostei, and the cerebellum covers the whole length of the brain, behind the prosencephalon. The external surface of the prosencephalon and cerebellum is not flat. The former is divided into four longitudinal lobes, and the latter into several areas by the median longitudinal and transverse grooves.

Ganglia of the sympathetic nerve are found in the haemal canal, one in each body-segment, and when the canal is filled with the vascular plexus, they are embedded in it.

The otolith is rather thick and the parts on each side of the median groove are nearly equal in the Scombridae. In the Cybiidae one side is longer than the other, and in *Gymnosarda* the longer side is very much elongated and is nearly twice the length of the other. In the Thunnidae the otolith is straight, and one side is much longer than the other. In the Katsuwonidae the otolith is very slender and the parts on both sides of the groove are equally well developed, the hind end being more or less swollen.

The olfactory organs are a pair of grooves in front of the eyes. Each groove or sac communicates with the exterior by a pair of pores, nostrils. The anterior nostril is generally small, while the posterior is more or less elongated, oblong in the Cybiidae, and quite a slit in the Scombridae and Plecostei. Beneath the anterior nostril, there is a group of olfactory leaves, about 30 in number, arranged radially, in the form of a rosette. In the Scombridae two nostrils are situated rather near each other, and the upper wall of the olfactory cavity is uniformly thin. There is a deep groove in the floor of the cavity before the ethmoid, and just behind the olfactory rosette. The cavity extends behind the groove. The inner opening of the posterior nostril lies above the groove or before it.

In the Cybiidae the olfactory cavity is rather small, and the two nostrils are close together, the whole cavity is nearly filled with the rosette of the olfactory leaves. In this family the posterior nostril lies more or less behind the rosette. The dorsal wall of the cavity is thin, but the border of the inner orifice of the posterior nostril is generally raised. Moreover the dorsal wall is thickened in *Sarda*. Generally the cavity does not extend behind the posterior nostril, and there is a fleshy dam behind the rosette and below the posterior nostril.

In the Thunnidae there is a space behind the rosette, thus the two nostrils are much separated. The anterior nostril is very minute. The rosette of the olfactory leaves is high and occupies the whole height of the cavity. The dorsal wall of the cavity is very thick.

In the Katsuwonidae the two nostrils are close together, and the cavity is much more depressed than in the Thunnidae. The passage of the anterior nostril is almost perpendicular to the surface of the head, while that of the posterior is more or less turned obliquely. The former has the uniform calibre, but the latter is wide at the inner orifice, and becomes gradually narrow towards the outer orifice. Between these nostrils there is a narrow groove on the roof of the olfactory cavity.

ABDOMINAL CAVITY.

In the Scombridae the height of the abdominal cavity is more than half the height of the body, and the cavity lies just beneath the vertebral column ;

but in the Cybiidae the cavity is more or less separated from the vertebral column, from the development of the haemal processes in many precaudal vertebrae. In the the Plecostei the coelomic cavity is low and narrow, as the haemal process of precaudal vertebrae is much better developed than in the Cybiidae. The height of the cavity is less than its breadth, and its roof is flat or convex, thatched with a broad proximal portion of ribs, and protected by the peritoneum, composed of thick bundles of connective tissue arising from the distal end of the precaudal haemal spines, and interwoven with each other at their root. These bundles of connective tissue are inserted at the ventral median line of the cavity, here too, their ends are interwoven. Generally speaking the visceral cavity of the scombroid fishes does not extend to the caudal portion, though some posterior ribs push their way into the lateral muscle, beyond the peritoneum, and lie on each side of the interhaemals. Thus the length of the abdominal cavity may approximately be known by measuring the distance of the anus from the gill-slit. In the genus *Auxis*, however, the genital gland extends beyond the origin of the anal, and grasps the interhaemals of the fin from both sides. Thus the abdominal cavity is also extended backward beyond the anus with the genital glands.

In the Scombridae the peritoneum is often dark coloured as in *Rastrelliger* and immature forms of *Scomber* probably owing to the body being broad, and abdominal wall thin, nearly vertical, and the light seems to transmit more or less; but in adult forms of *Scomber*, Cybiidae, and Plecostei the peritoneum is little affected by the light, as the abdominal wall is thick and is turned obliquely downwards. Thus the peritoneum remains nearly colourless in these groups. The peritoneum is developed round the visceral organs and envelops them, and the generative organs, rectum, etc. are suspended from the dorsal wall of the body-cavity by the peritoneum. The peritoneum is very thick at the posterior part of the body-cavity in *Thunnus germo*.

AIR-BLADDER.

The air-bladder is sometimes present and sometimes absent, and this is the case even among species of the same genus. The air-bladder is generally absent in those fishes living always near the surface of the sea. Thus it is entirely wanting in the fishes of the Katsuwonidae. It is, however, rather difficult to understand that *Acanthocybium* which is always found near the surface has a well developed air-bladder, while *Cybium niphonium* which has a rather wide range of vertical distribution lacks it. The air-bladder is more or less fusiform, and generally thickened at the anterior part.

In the Scombridae the air-bladder is generally present, being absent in *Scomber scombrus* only. In *Scomber japonicus* the air-bladder is fusiform, narrow and pointed at both ends. It occupies a little more than half the length of the abdominal cavity. Its wall is very thin.

In the Cybiidae the air-bladder is not found in *Cybium niphonium*, *C. koreanum*, and *Sarda orientalis*. In *Gymnosarda nuda* the air-bladder is large and thick-walled.

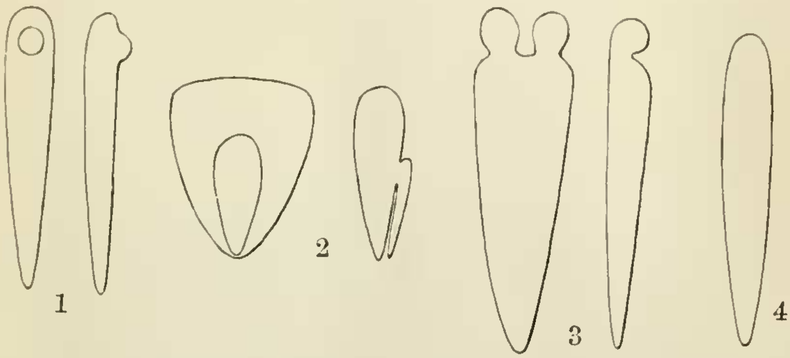


Fig. L. Air-bladder of tunnies. 1, *Thunnus germo* (dorsal and side views); 2, *Thunnus orientalis* (dorsal and side views); 3, *Parathunnus mebachi* (dorsal and side views); 4, *Neothunnus macropterus* (ventral view).

In the Thunnidae the development of the air-bladder is very interesting. In *Thunnus germo* the air-bladder is narrow, but long, running the whole length of the abdominal cavity, and has a median dorsal swelling at the anterior end. In *Thunnus orientalis* the air-bladder is triangular, very wide, and straight at the anterior end, occupying the entire breadth of the abdominal cavity, but it is short, and becomes gradually narrow behind, pointed at the posterior end. It is a little longer than half the length of the abdominal cavity. The external wall is uniformly thin. The internal wall is finely reticulated. At the middle of the roof of the air-bladder, there is a large round hole, which leads to an accessory conical cavity, extending from the hole behind to the posterior end of the principal cavity. At the anterior end of this upper accessory cavity a vein pours to a segmentary vein. In immature tunnies the air-bladder is very small, and almost collapsed. The air-bladder of this species has a pair of slight swellings along the anterior side.

In *Parathunnus mebachi* the air-bladder is a little narrower than the roof of the abdominal cavity; but occupies the entire length of the cavity, at the anterior end the air-bladder is divided into two large coeca, by the dorsal aorta in the middle, and is separated by the cutaneous arteries from the principal cavity. The internal wall is finely reticulated.

In *Neothunnus macropterus* the air-bladder is narrow, and is protected by a very thick mass of connective tissue from the ventral side. This thick mass of connective tissue is utilized as a material in making glue. On the middle of the dorsal wall a large vein is found with radiating venules from all sides.

The red gland is developed at the anterior part of the air-bladder, near the point where the artery for the air-bladder enters. The air-bladder of the Scombridae and Cybiidae receives blood from the dorsal aorta at several points, and pours its venous blood to the posterior cardinal vein at several spots; but in the Plecostei the arterial blood is received from a special branch of an artery, running along the right hand side of the stomach, and the venous blood pours to the caudal or the posterior cardinal vein through a segmental vein. Thus the arterial system of the air-bladder belongs to the axial system in the Scombridae and Cybiidae, but to the visceral system in the Plecostei.

DIGESTIVE SYSTEM.

The mouth-cavity is black in the Scombridae, black or greyish in the Cybiidae and Thunnidae, and silvery or colourless in the Katsuwonidae. The tongue is small, narrow, and black in colour, and far behind the symphysis of the lower jaw in the Scombridae; broad, flat, and generally greyish in the Cybiidae; greyish in the Thunnidae; and silvery white, medium in size, and the membrane at the lateral margins is turned upward in the Katsuwonidae. The surface of the tongue is granulated in the genus *Scomber*, armed with villous teeth in *Gymnosarda* and Thunnidae, and quite smooth in *Acanthocybium*, in many species of the genus *Cybium*, and in the fishes of the Katsuwonidae.

The development of the gill-rakers on the branchial arches has a close relation with the nature of food. The gill-rakers are strainers, and chiefly serve to prevent the escape of food from the branchial cleft, thus they are best developed in the plankton-feeders, such as mackerels and bonitos; but they are poorly developed in voracious forms, such as seerfishes, and are entirely wanting in *Acanthocybium*. At the same time the gill-rakers may serve "to prevent any solid particles from passing into the gill-clefts and clogging or otherwise injuring the branchial filaments." Gill-rakers are best developed on the external side of the first branchial arch. They are long and bar the space between the opercle and the branchial arch. Other series of gill-rakers are developed on the internal side and bar the intervals between branchial arches or the interval between the branchial arch and the lower pharyngeals. Gill-rakers on the external side of the branchial arch are directed forward, while those on the internal side are directed backward. Gill-rakers lie close to the branchial arch when the mouth is closed; but are separated and make angles with the branchial arch, when the mouth is open. The inner or upper side of the gill-rakers is rough, armed with minute tooth-like prickles.

In the Katsuwonidae the gill-rakers on the internal side of the branchial arches are well developed. The good development of gill-rakers on the upper arm of the first and second branchial arches is remarkable.

In the Scombridae the gill-rakers are weak, longer than the gill-lamellae, and very numerous and closely set. Each gill-raker has two rows of alternating diverging flexible filaments, giving a villous appearance to the mouth-cavity. In this family the gill-rakers on the inner side of each branchial arch are pretty well developed. In *Rastrelliger* the gill-rakers are enormously long, so that they may be seen from the gape of the mouth. In the Cybiidae the gill-rakers are shorter than the gill-lamellae, rod-like, and few in number. Fine but stout tooth-like processes on the inner side of the gill-rakers are in two or more rows. In most species of this family external gill-rakers only are developed. In *Sarda chilensis*, however, I found a few, small internal gill-rakers on the first gill-arch.

In the Plecostei the gill-rakers are thin, narrow lamellae with villous teeth on the inner side. As the gill-rakers are long, and the gape of the mouth wide, the former may easily be seen in the latter. In the species in which the number of gill-rakers is large, they are well developed in other respects as well, so that among the Japanese tunnies, *Thunnus orientalis* has the best developed gill-rakers, and in the genus *Katsuwonus* the gill-rakers are better developed than in the genus *Thunnus.* The inner or axial side of gill-rakers and also calcareous grains on branchial bones are covered with villous teeth. Teeth near the oesophagus are generally a little larger than others. Thus teeth on the lower pharyngeals and the hypobranchial segment of the fourth branchial arch are larger than those on other branchial bones.

In the Katsuwonidae the second, third, and fourth gill-arches carry numerous, thin, elongated gill-rakers, also on the posterior side. In *Katsuwonus,* moreover, the inner margin of the gill-rakers on the anterior margin undulates.

Stomach (figs. 3, 5, 6). In the Scombridae the stomach is a rather thin walled, conical sac, suspended from the roof of the coelomic cavity of the peritoneum, and weak longitudinal folds (about 16 in *Scomber japonicus*) are found near the two orifices, pyloric and cardiac. The cardiac orifice is more or less constricted. The pyloric orifice, situated about midway of the stomach is long and ascending, i. e. turned anteriorly. It opens into the duodenum with a crescent-shaped orifice, as its posterior wall is enormously thickened. In the Cybiidae and Plecostei the stomach is a very long conical sac, the posterior end of which almost reaches the anus. The pylorus, situated quite near the oesophagus, is on the left side of the stomach, and is more or less turned posteriorly. The wall of the stomach is thick, tough, and rich in deep, longitudinal folds, some of which run into the pylorus. The food is chiefly digested in the sac-portion, where the soft parts are almost entirely dissolved and the framework of the hard skeleton is also broken to pieces. The digestive fluid of the stomach is acid in reaction, very powerful, soon dissolving the skin of fish or cuttle-fish, then muscles, and lastly bones. The calcareous portions of the skeleton are dissolved leaving the chondrous substance behind. The gelatinous tissue or tunicine of pteropods, tunicates, &c., jaws, pens, and lenses of cuttle-fish are scarcely changed in the stomach. The stomach of tunnies is very loosely covered outside with the thick peritoneum, and the blood-vessels to the stomach lie under the membrane.

The pylorus is more muscular than the sac-portion, and generally rather short. It runs to the left side of the stomach. In the Scombridae and in the majority of the remaining teleosts the pylorus is ascending. In the Cybiidae the pylorus is slender, variable in length, and is more or less dilated near the distal end, forming a special diverticulum, just before the boundary with the duodenum. In the Plecostei the pylorus is rounded or more or less ovoidal, being thicker at the proximal portion, and more or less twisted to the right-hand side at the posterior end. The duodenum is separated from the pylorus by a well marked constriction, and suddenly dilates, hence it is more or less sac-shaped. It is thin walled, widest just behind the pylorus, overlapping the latter a little and becoming gradually narrow. It is curved forward, touching the dorsal posterior surface of the liver, and is bent dorsalward, then backward, and lastly bending to the right-hand side, passes to the intestine. In more or less tainted fish the duodenum is the first to dissolve, probably by its own enzymes, i. e. by the action of autolysis. To this portion of the intestine the pyloric coeca and cystic duct open their apertures. The latter duct enters at the anterior side of the duodenum, just near the pylorus, while the former generally open at the posterior side with many apertures, distributed in one or several rows. The pyloric coeca are generally yellowish in colour.

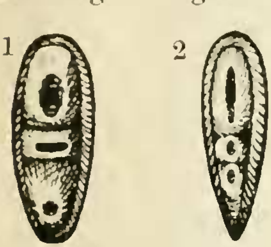
Longitudinal folds of the stomach are mostly about 20 in the Cybiidae, but in the Thunnidae there are usually 30–40, but in the Katsuwonidae they decrease in number again, to about 20 in *Katsuwonus*, 12 in *Euthynnus*, and nearly indistinct in *Auxis*.

Pyloric coeca. In the Scombridae (fig. 1) the pyloric coeca are coarse, numerous, and each coecum communicates directly with the duodenum (*Scomber*), or a few or several coeca coalesce at the root and open by a common orifice (*Rastrelliger*). They are crowded in a long and more or less triangular tract on the posterior or ventral side of the duodenum. Those coeca near the pylorus are long, and their length gradually diminishes in proportion to the distance they are from it. These numerous coeca are connected by loose connective tissue traversing them.

In the Cybiidae (fig. 6) and Plecostei (figs. 3, 5) the pyloric coeca are remarkably well developed and assume a conspicuous size as a mass. The size of each coecum, however, becomes small as the development of the pyloric coeca as an organ advances. In these groups of fish the coeca do not open directly to the duodenum, but to its tubular outgrowths of varying length. These tubules are dendritically branched, have a rather thin but tough wall, and some longitudinal grooves inside. They are more or less capable of distention. Each branch of the pyloric tubules with tufts of coeca is enclosed by a membrane of connective tissue, and the whole mass of the pyloric coeca is again enclosed and connected compactly by a common membrane, the peritoneum. In pyloric tubules we find a viscous, milky fluid; and sometimes half digested particles of food as well, when the stomach is glutted. Mr. YU YOKOYA examined for me the nature of enzymes in the pyloric coeca of *Neothunnus macropterus*, and obtained the result that amylase and protease are present, but he could not detect the presence of lipase. This result confirms other authors' results of investigations, and points out that the chief function of the pyloric coeca is digestive. In this inquiry glandular portion only was used, so that there was little fear of mixing of gastric juice.

In the Cybiidae the number of pyloric tubules is few (2-6), and small one of them is often found on the anterior concave side. The coecal portion is sparingly branched. In the Plecostei the number of pyloric tubules is a little more numerous (5-10), and their short terminal branches carry tufts of simple coeca. Two or three small tubules are found on the concave side of the pylorus in the Katsuwonidae. In the Thunnidae the size of coeca is not uniform, those near the distal end of the longest pyloric tubule being larger than others. The tubule next to the pylorous is longest, and succeeding ones rather suddenly decrease in length. These tubules are generally disposed at the posterior side in a line along the entire length. Their orifices to the duodenum are variable in size and form, being round, oblong, or sometimes slit-like.

Intestine. The duodenum is transferred to the small intestine at the spot where the alimentary canal is bent backward, i. e. at the junction of the ascending and descending parts of the alimentary canal. The length of the small intestine is very variable. It is short and straight in *Grammatorcynus* and Katsuwonidae, and long and more or less folded in the Scombridae, Cybiidae (except *Grammatorcynus*) and Thunnidae. In *Rastrelliger*, some species of *Cybium*, and fishes of the Thunnidae the intestine is comparatively and nearly uniformly slender; but in these cases the intestine is always much elongated. The intestinal tract is a little more slender than the duodenum. In the Katsuwonidae the small intestine is very short, being nearly eqnal in length with that of the abdominal cavity. But the intestine is often thicker than the rectum, and many weak longitudinal folds are found in it. Sometimes the rectum is thicker than the small intestine. In this family the intestine is nearly equal in length with the rectum. The rectum is relatively long in *Scomber* too. The boundary between the small intestine and the rectum is indicated by a transverse ridge inside. In the so called scombroid fishes the length of the intestine seems to have but little connection with the nature of food, as voracious fishes of the Cybiidae have often a long intestine, folded several times, and fishes of the Katsuwonidae, which feed on medium sized plankton, have a short, straight intestine. *Rastrelliger* which is a plankton-feeder has a very long intestine, more than 5 times as long as the length of the abdominal cavity. Usually the colour of the undigested ingredients of food differs in different tracts of the intestine. In the scombroid fishes the alimentary canal and genital and urinary ducts open to a common depression which is very shallow and communicates to the exterior with an elongated cleft. The anus, genital pore, and urinary pore all open independently on respective papillae. Of these the anus is the largest. The posterior wall of this cloaca-like space is more or less darker in colour than the anterior. When we handle the viscera of a tunny, more or less stale, with naked hands the wet portion becomes itchy, and in certain people the contact occasions small tumors of the skin. This is probably due to the formation of ptomain. In the viscera of a stale fish we often find small crystals on the external surface of the mass of the pyloric coeca.



1, *Scomber japonicus*
2, *Neothunnus macropterus*

Fig. M. External aperture of the cloacal cavity (enlarged), showing from above the anal, genital, and urinary openings on the respective papilla.

Liver (figs. 2, 3, 5, 6). The liver is a large brownish organ, generally divided into three lobes, and situated just behind the diaphragm, and covers the anterior and ventral part of the stomach. In the Scombridae the live, differs remarkably in form from the other allied fishes. It is a small, undividedr more or less triangularly pyramidal organ, with three trenchant edges. It is situated at the left, anterior corner of the abdominal cavity. The right hepatic vein is found at the attenuated margin of the right, anterior corner. The middle and right lobes are scarcely developed. In the Cybiidae we find three lobes of the liver, but their respective size and form are variable. Generally the right lobe which is scarcely developed in the Scombridae, is best developed, but the left and middle lobes are poorly developed. In *Gymnosarda*, however, the left lobe is best developed.

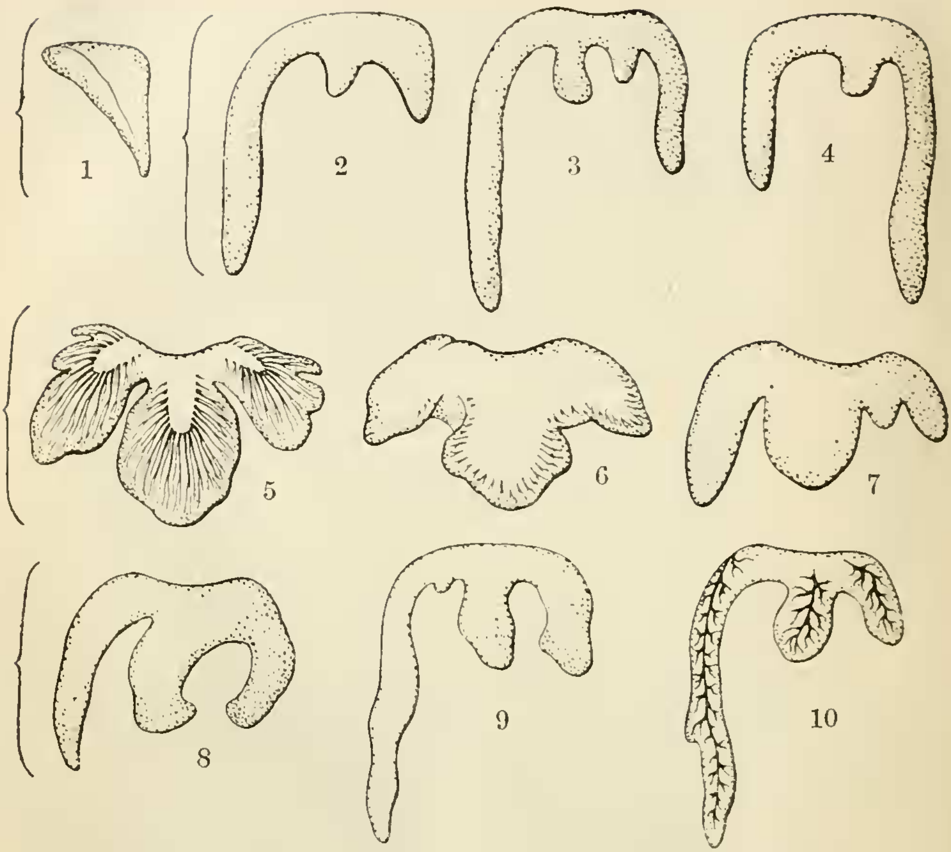


Fig. N. External view of the liver. 1, *Scomber japonicus*; 2, *Cybium niphonium*; 3, *Sarda orientalis*; 4, *Gymnosarda nuda*; 5, *Thunnus orientalis*; 6, *Parathunnus mebachi*; 7, *Neothunnus macropterus*; 8, *Katsuwonus pelamis*; 9, *Euthynnus yaito*; 10, *Auxis maru*.

In the Cybiidae as well as in Scombridae the surface and the outline of the liver are smooth. In the Thunnidae the three lobes of the liver are subequal, but in the Katsuwonidae the lobes of the liver are unequal in size, the right lobe being best developed, and the left lobe is often not well defined. In *Thunnus* (fig. 3) the external surface of the liver is marked with fine venules running very close together, and at the anterior middle portion of the liver, near the spots of emergence of hepatic veins, the liver is very thin, being composed of hepatic venules only. Moreover the liver is divided into many irregular lobules at the margin as well as at the internal or axial side, where large masses of rete mirabilis of blood-vessels are found. In *Parathunnus* the external surface of the liver has a few short venules near the posterior margin; but in *Neothunnus* no venules are found at the external surface. In these two genera the lobes of the liver are not deeply cut, and in the latter genus the right lobe is a little longer than the other lobes. In *Euthynnus* and *Auxis* (fig. 2) the right lobe of the liver is enormously elongated, almost reaching the anus, while the left lobe is often inconspicuous, being not separated by a distinct indentation from the middle lobe. In *Auxis* moreover dark and thick dendritic figures of the hepatic vein are clearly discernible on the external surface of the liver.

The gall-bladder (figs. 1–3, 5, 6) is an enormously elongated sac, running along the intestine, on the inner side of the right lobe of the liver. The bladder becomes narrow at the anterior part and passes gradually to the cystic duct which is bent backward along the inner side of the middle lobe of the liver, and opens to the duodenum with a narrow duct, ductus choledochus. To the cystic duct three or more hepatic ducts open. These are more or less dendritically branched in the liver. In the Scombridae the gall-bladder is elongated and receives some slender ducts (3 in *Scomber japonicus*). In the Katsuwonidae the hepatic duct in the right lobe of the liver is very long, running the whole length of the lobe. The gall-bladder is greenish in colour, but it is sometimes purplish in a stale fish.

The spleen (figs. 1–3, 5, 6) is a compact, elongated body, more or less compressed, and dark red or brownish in colour. It generally lies close to the junction between the duodenum and the small intestine. It is rather small in the Scombridae and Cybiidae, but in the Thunnidae it is very well developed and is attached to the anterior part of the fold of the small intestine, occupying the space enclosed by the duodenum, and the intestinal tract to the second bend. In the Katsuwonidae the spleen is again small and lies exterior to the intestine. In the genus *Sarda* the spleen is much separated from the liver.

RESPIRATORY SYSTEM.

In the so-called scombroid fishes the gill-openings are very wide, extending from the origin of the chin to the posterior ventral margin of the cranium, and the branchiostegal membranes not being united at the anterior end, remain free from the isthmus. In the Scombridae we find a slight depression at the posterior, dorsal margin of the gill-opening, just anterior to the origin of the pectoral. This depression together with the soft flappy portion of the opercle above it, make easy the escape of foul water from the gill-chamber. In *Rastrelliger*, moreover, a slight depression or groove is found on the hind ventral margin of the gill-opening, or at the lower, anterior margin of the shoulder girdle. Such structures of the gill-opening as the flappy portion of the opercle opposite to the slight depression of the gill-opening, and another depression on the posterior ventral margin are often found in fishes of the Carangidae as well, and we see that there is some relation between these two families.

The branchiostegals are slender, seven or eight in number, and the membranes connecting them are rather wide and extensive. In the Scombridae the branchiostegals are dissimilar in breadth and form, posterior ones becoming broader and much more curved or bent.

In the Cybiidae the branchiostegals are slender, and the membrane connecting them is extensile. In the Plecostei the posterior branchiostegals are more or less broad, and the free margin of the membrane is much thickened, hence tough from the development of connective tissue. The membrane is nonextensile and remains fastened to the inner side of the opercle, a little removed from its margin, like an inner rim of a lid to a base.

The pseudobranchiae are equally well developed in the Scombridae, Cybiidae, and Plecostei.

The branchial lamellae are very thin, and closely set, nearly equally in all scombroid fishes; but their length and breadth vary greatly in different families. Their length is proportional to the breadth of the opercle. In the Scombridae the gill-lamellae are short and narrow, about half the length of the upper arm of the first gill-arch. In the Cybiidae they are a little longer than half the length of the upper arm of the first gill-arch, and in the Plecostei they are equal in length with the latter. In the Plecostei each branchial filament is strengthened on the proximal, axial side of each gill-arch with many minute transverse rods.

In *Acanthocybium* the branchial lamellae anastomose with each other as in the Xiphiidae, but in the former the anastomosis is limited to the proximal portion of the lamellae, not over the whole extent of the gills as in the latter.

VASCULAR SYSTEM.

In the vascular system too, we find many very important points of difference among the scombroid fishes. Especially the order Plecostei presents many characteristic features, remarkably different from all the other fishes. The chief features of difference are the greater quantity of blood, greater number of blood-vessels, and larger heart. The most noteworthy difference is the development of the cutaneous vascular system, not found in the Teleostei, and peculiar vascular plexus in the lateral muscle, and enormously developed vascular plexus under the liver, or in the haemal canal. Therefore we distinguish three different systems of blood-circulation in the Plecostei, namely vertebral, visceral, and cutaneous. These three systems have respectively a peculiar feature in the Plecostei; but the peculiarity of the vertebral system is alternative with that of the visceral. The cutaneous system is very conspicuous and quite characteristic to the Plecostei, and has a correlation with the presence of the dark red portion of the lateral muscle, round the vertebral column from the development of sheet-like vascular plexus. It is very remarkable that such a conspicuous and peculiar system of circulation remained almost unknown to science. Though the keen eyes of CUVIER (12) discovered it in the common tunny of Europe, he did not put much weight on it, so that he described it rather in passing in the following lines:—

> "Lorsqu'on a levé la peau du thon, on trouve sous la ligne laterale un grand vaisseau, qui donne de sa face externe, en dessus et en dessous, beaucoup de branches dans les muscles voisins. Sa face interne est criblée d'un nombre infini d'orifices d'autres branches, qui vont se perdre sur une membrane glanduleuse épaisse".

After CUVIER no one has studied nor even mentioned the peculiar blood-vessels. In 1836, ESCHRICHT and MÜLLER (19) published an interesting paper on the peculiar plexus of blood-vessels among the viscera of the common European tunny. In that paper they give a figure, showing the origin of the cutaneous arteries (Taf. III, fig. 3); but identified them with prejudice as the axial arteries, and did not trace further. In 1915 I published a paper on the peculiar circulatory system (44) in the "Suisan Gakkwai Hō" (Proceedings of the Scientific Fishery Association) Vol. I, and in 1918 another paper in the

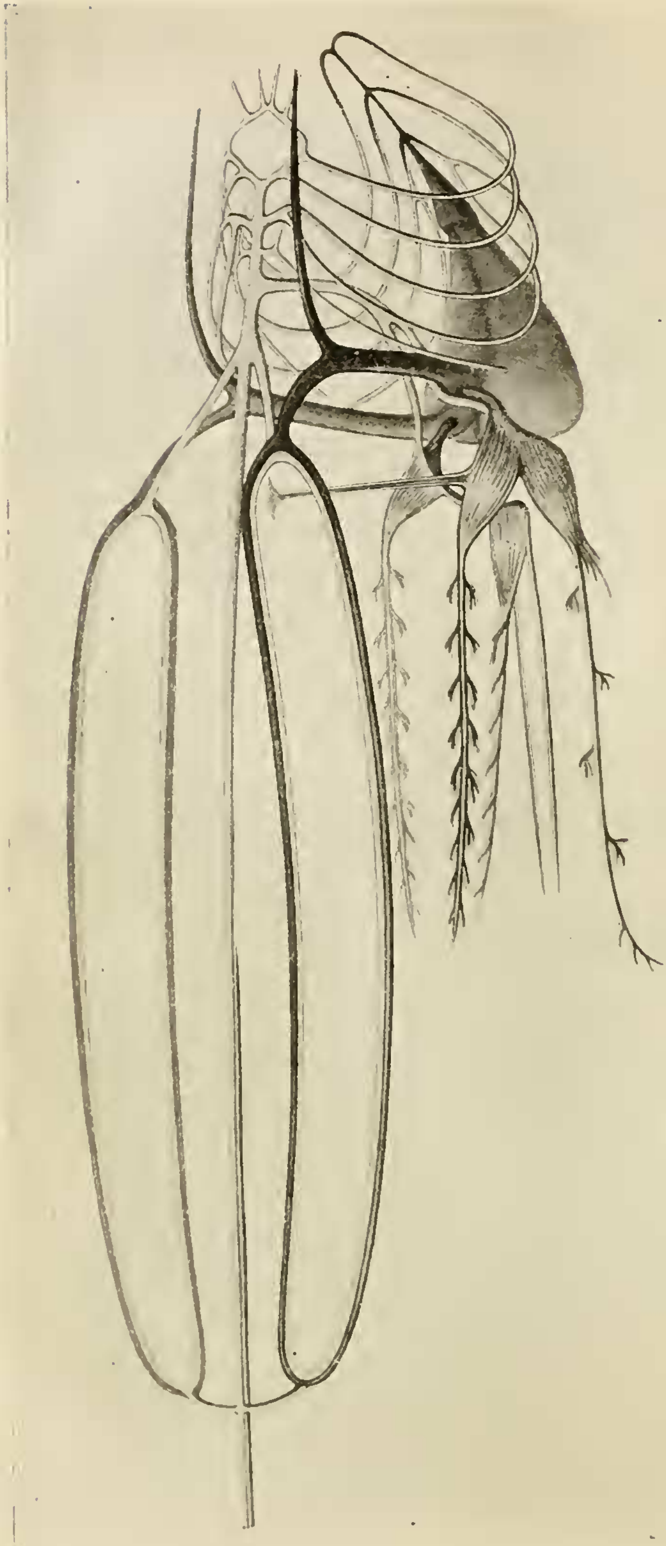


Fig. O. Diagram showing the vascular system of *Thunnus orientalis*.

same journal, Vol II (46).

Besides the peculiar cutaneous system and vascular plexuses on the inner side of the liver described by ESCHRICHT and MÜLLER there is another peculiar plexus in the haemal canal of the vertebral column in *Neothunnus* and Katsuwonidae. In these fishes the vascular plexuses on the inner side of the liver and fine hepatic veins on the outer side of the liver are wanting. Therefore these hepatic plexuses seem to be the alternative of the plexuses in the haemal canal. Both the hepatic plexuses and the plexuses in the haemal canal consist of blood-vessels entirely filled with blood-corpuscles.

In the Plecostei the caudal peduncle is very slender and full of strong tendons, thus there is little space for the sure circulation of blood, and here blood-vessels find a safe passage in the substance of the vertebrae themselves.

The higher temperature of the body than the surrounding water, and consequently great activity of fishes of the Plecostei is undoubtedly due to the peculiar circulatory systems above described.

Venous system. In the Scombridae (fig. 1) the chief vertebral venous system consists of the jugular veins, Cuvierian ducts, posterior cardinal vein, lateral vein, and segmental veins. The visceral system consists of the hepatic veins, hepatic portal veins, and the genital veins from the gonads. The genital veins unite with the posterior cardinal vein separately. The posterior cardinal vein lies below the dorsal aorta and communicates with the Cuvierian duct of the right side. The segmental veins carry venous blood along the neural and haemal processes and intermuscular bones, generally in every other myotome, alternating with segmental arteries. The venous blood from the surface of the body is collected in these segmental veins, but chiefly in those running to the inner surface of the wedge-shaped superficial reddish muscle and then along intermuscular bones. These segmental veins are short and small. The venous blood in the lateral wall of the abdominal cavity is chiefly collected in the segmental veins along the peritoneum and pour to the posterior cardinal vein at the root of the pleural ribs, and partly to the lateral veins running along the ventral median line, collecting some inferior segmental veins in the antero-inferior part of the lateral body wall. The Cuvierian ducts are large vertical ducts, running along the sides of the oesophagus, behind the pericardo-peritoneal septum and join the sinus venosus.

The venous system of the Cybiidae (fig. 6) is nearly similar to that of the Scombridae; but differs in the development of the renal portal system in the precaudal region, where some segmental veins running along neural processes and intermuscular bones are minutely divided in the kidneys. Nearly at the posterior end of the precaudal region the cardinal vein leaves the haemal canal and runs obliquely downward to clear some preceeding haemal arches and short haemal spines and passes through the kidney, receiving numerous venules there and taking a more or less ascending course rejoins the dorsal aorta in the haemal canal. The segmental vein is not found in every segment, but almost in every other segment, alternating with the segmental artery as in the Scombridae.

In the Plecostei the venous system differs greatly from that of the Teleostei, as stated above, moreover there is a great variety in the system in different forms of the order. In the genus *Thunnus*, the most primitive type of the Plecostei, the cutaneous system is best developed, and the vertebral system is abortive, the posterior cardinal vein being wanting. A short, slender caudal vein is found in the place of the posterior cardinal vein. The caudal vein joins at the middle part to the transverse commissure of the cutaneous veins and thus communicates indirectly with the Cuverian ducts. A pair of cutaneous veins, are found on each side of the body, on the epaxial and hypaxial sides of the lateral median line. These two veins run almost parallel, and quite near each other. They run deep into the myotome of the fourth vertebra, at the hind margin of the myotome, and unite a little below the surface of the body. The confluent vessel runs obliquely anteriorly, passes under the proximal slender part of the third rib, and joins the Cuvierian duct of the respective side, after collecting many renal venules. The right and left cutaneous veins are united by a transverse commissure in the caudal portion. This transverse commissure of the cutaneous vein is found in all the forms of the Thunnidae. Segmental veins, both cutaneous and the vertebral, are found in every myotome.

In *Parathunnus* (fig. 4) the cutaneous veins of both sides pass through the myotome of the sixth vertebra, and each uniting to a large vein running below the fifth rib, pour into a transvers canal behind the pharyngeal muscles. The transvers canal joins the right Cuvierian duct after uniting with a short renal vein. The caudal vein is very slender as in the genus *Thunnus*, and

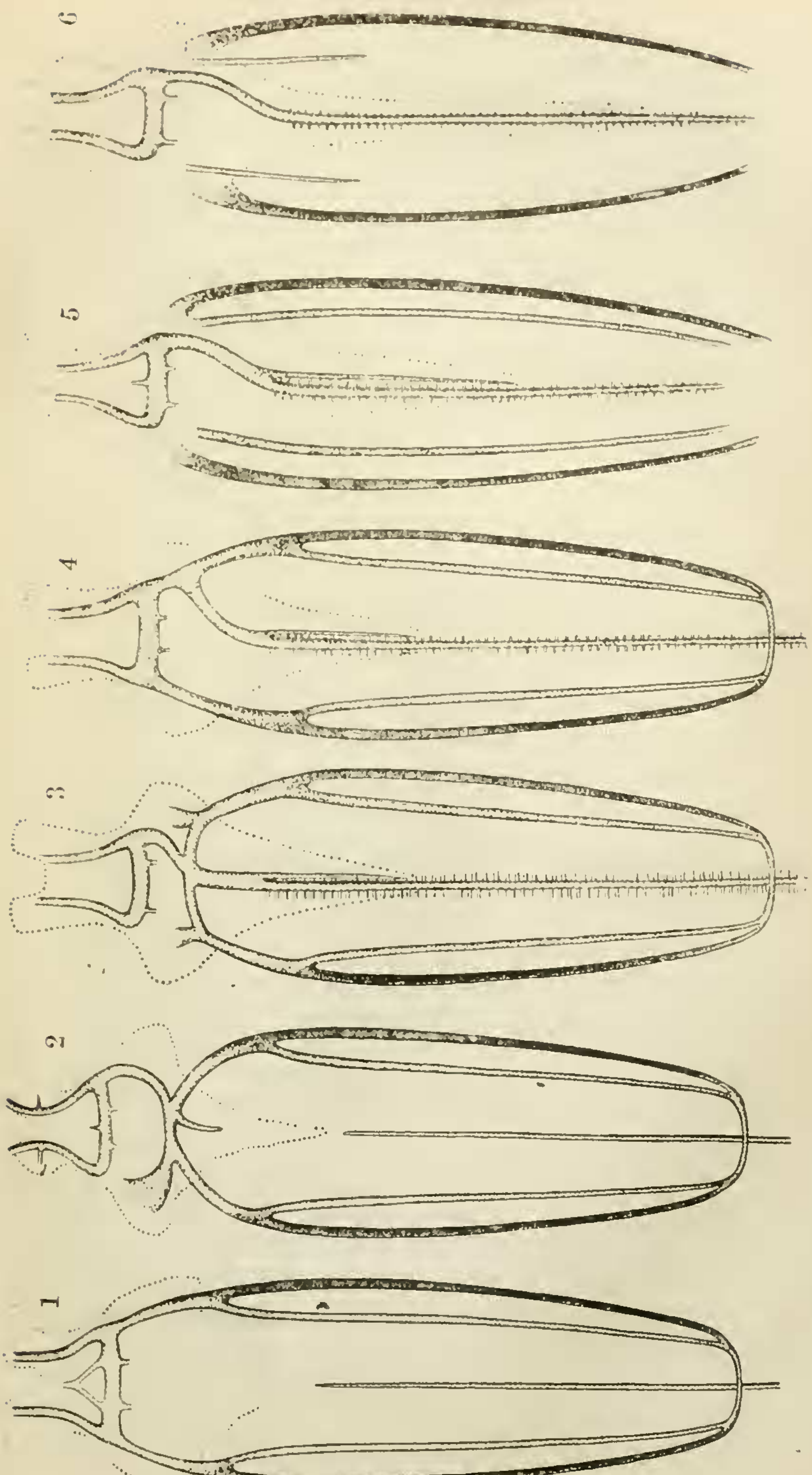


Fig. P. Diagram showing the vertebral and cutaneous venous systems of Plecostean fishes. *1, Thunnus orientalis*; *2, Parathunnus mebachi*; *3, 4, Neothunnus macropterus*; *5, Katsuwonus pelamis*; *6, Euthynnus* and *Auxis*. The dotted line shows the outline of the renal organ.

does not unite with the Cuvierian duct directly. In this genus most of the segmental veins running along the haemal spines in the precaudal region and also in the anterior part of the caudal region are divided into many venules near the vertebral column, so that their blood does not return directly to the heart, but seems to be collected to venules above the vertebral column and in the dark red portion of the lateral muscle. This is very remarkable. The segmental veins in the caudal region unite to a slender caudal vein.

In *Neothunnus* the posterior cardinal vein is very conspicuous, and gives off a peculiar plexus in the haemal canal, and at last joins the right Cuvierian duct. The cutaneous veins are united by an anterier transverse commissure as in *Parathunnus*, or sometimes each of them pour directly into the Cuvierian duct of the respective side as in *Thunnus*. A short slender renal vein runs under the posterial cardinal vein and is united to it.

In the Katsuwonidae the vertebral venous system consists of the posterior cardinal vein, jugular veins, Cuvierian ducts, lateral veins, cutaneous veins, segmental veins, and subspinal plexus. The posterior cardinal vein is connected with a remarkably well developed plexus of venules in the haemal canal and joins the right Cuvierian duct as in the genus *Neothunnus*. The cutaneous veins do not join the Cuvierian duct directly, nor are they united by a transverse vessel in the thoracic region to the posterior cardinal vein, but are divided to renal portals. Thus these cutaneous veins differ from the similar veins of the Thunnidae. Moreover the lower cutaneous vein of this family is not homologous to the lower branch of the cutaneous vein of the Thunnidae. The epaxial and hypaxial veins originate in different myotomes and they do not form a loop at the caudal region, nor are they connected by a transverse commissure. In *Katsuwonus* the epaxial and hypaxial cutaneous veins are nearly equal in size and length, and though they are not straight they are nearly equally distant from the lateral median line of the body. These veins run anteriorly and to a deeper part of the body, passing through the myotome of the fifth vertebra. The epaxial vein passes below the first rib, while the lower passes above it. These two veins receive blood respectively from the sheets of vascular plexus on the dorsal and ventral sides of the dark red portion of the lateral muscle. In the other genera, *Euthynnus* and *Auxis*, the epaxial cutaneous vein is very thick and runs close and parallel to the lateral median line of the body, running to the deeper part of the body between the myotomes of the fourth and fifth vertebrae. The chief cutaneous segmental veins are united to the epaxial cutaneous vein, and sheets of vascular plexus surrounding the dark red portion of the lateral muscle are connected with the vein. The hypaxial cutaneous vein is remarkably short, slender, and zigzag in its course, disappearing from the surface of the body just behind the postclavicle and before the myotome of the first vertebra. In the Katsuwonidae the hypaxial cutaneous vein always passes before and above the first rib. The posterior cardinal vein leaves the haemal canal from the fourteenth vertebra or a still more backward position. Anterior to that point the posterior cardinal vein is more or less separated from the dorsal aorta, receiving several short but comparatively large veins at both sides of the dorsal aorta, and these veins are formed from parallel venules of the vascular plexus in the haemal canal or "kurochiai" in Japanese. At the same point an inferior posterior branch joins the posterior cardinal vein. The branch is a slender renal vein as in *Neothunnus*. The cardinal vein and the dorsal aorta too are situated close to the lower side of the haemal canal, sending a thick rod of vascular plexus above, which fills up the broad canal. The kurochiai appears from the segment of the fifth vertebra in *Katsuwonus*, from that of the sixth vertebra in *Euthynnus yaito*, from that of the ninth in *Neothunnus*, and tenth or twelfth in *Auxis*. In the latter genus the epaxial cutaneous vein passes between the two accessory cones of the lateral muscle (fig. 2).

The visceral venous system of the Plecostei consists of some hepatic portal veins, hepatic veins, and genital veins. The chief difference from the Cybiidae and Scombridae lies in the genital veins, which directly join the Cuvierian ducts. In the Thunnidae the hepatic portal veins are more or less divided into plexuses or parallel venules before entering the liver. The plexus is most remarkably developed in *Thunnus*. In this genus the venules are interlaced with arterioles of the coeliac artery. Each plexus is as large as a fist, and is more or less conical. In another genus, *Parathunnus*, only venules are found in the plexus, consequently the plexus is thin, elongated, and in the genus *Neothunnus* the plexus is not found at all, but instead of a single trunk, the hepatic portal veins are composed of several parallel venules. Concomitantly with the development of the peculiar plexus on the internal side of the liver, the hepatic veins are divided very finely and run quite near the external surface of the liver. In *Parathunnus* venules of the hepatic veins on the external surface of the liver are rather short and sparce, while in *Neothunnus* venules of the hepatic veins are few, large and are not found at the external surface of the liver. In immature forms of our common tunny venules on the surface of the liver are short, remarkably shorter than in the adult. In the Katsuwonidae neither the plexus nor the parallel venules among the viscera nor those on the external surface of the liver are found. In *Auxis*, however, black dendritic figures of the hepatic veins are noteworthy on the external surface of the liver. In *Euthynnus* and *Auxis* the right lobe of the liver is elongated, and hepatic portal veins from the pyloric cocca run in many transverse canals to the lobe.

Heart. The heart lies just before the pericardo-peritoneal septum, in a more or less conical space, enclosed and protected by the lower pharyngeals, clavicles, and pelvic girdle. The organ consists of a sinus venosus, auricle, ventricle, and bulbus arteriosus. The sinus venesus is thin-walled and spacious, formed by the union of the Cuvierian ducts below the oesophagus. The sinous communicates with the auricle by a round opening. The auricle is a more or less flattened sac with a triangular outline, covering the dorsal anterior face of the ventricle. The inner side of its wall is reticulated with muscle bundles. The ventricle is firm, thick walled, more or less tetrahedral in shape, with an anterior vertex, ventral edge, and posterior base. In the anterior dorsal face the ventricle is connected with the preceding chambers. Thus here the course of blood-circulation is changed. The posterior face or the base is flat or rather a little concave. The bulbus arteriosus is a laterally compressed sac, ovoidal in form, with a well developed muscular wall. The sinu-ventricular orifice is elliptical with two large pocket-shaped valves, while the auriculi-ventricular orifice is roundish, guarded with four hood-like valves. The size of the heart is remarkably large in the Plecostei as it propels more blood than in the Teleostei. The form of the heart is different in the Plecostei, the base of the ventricle is nearly vertical in the order, while in the Scombridae and Cybiidae it is oblique.

Arterial system. The bulbus arteriosus gradually passes to the short ventral aorta which gives off four pairs of afferent branchial arteries. The aeriated blood in the gill-arches is mostly carried dorsalwards to the efferent

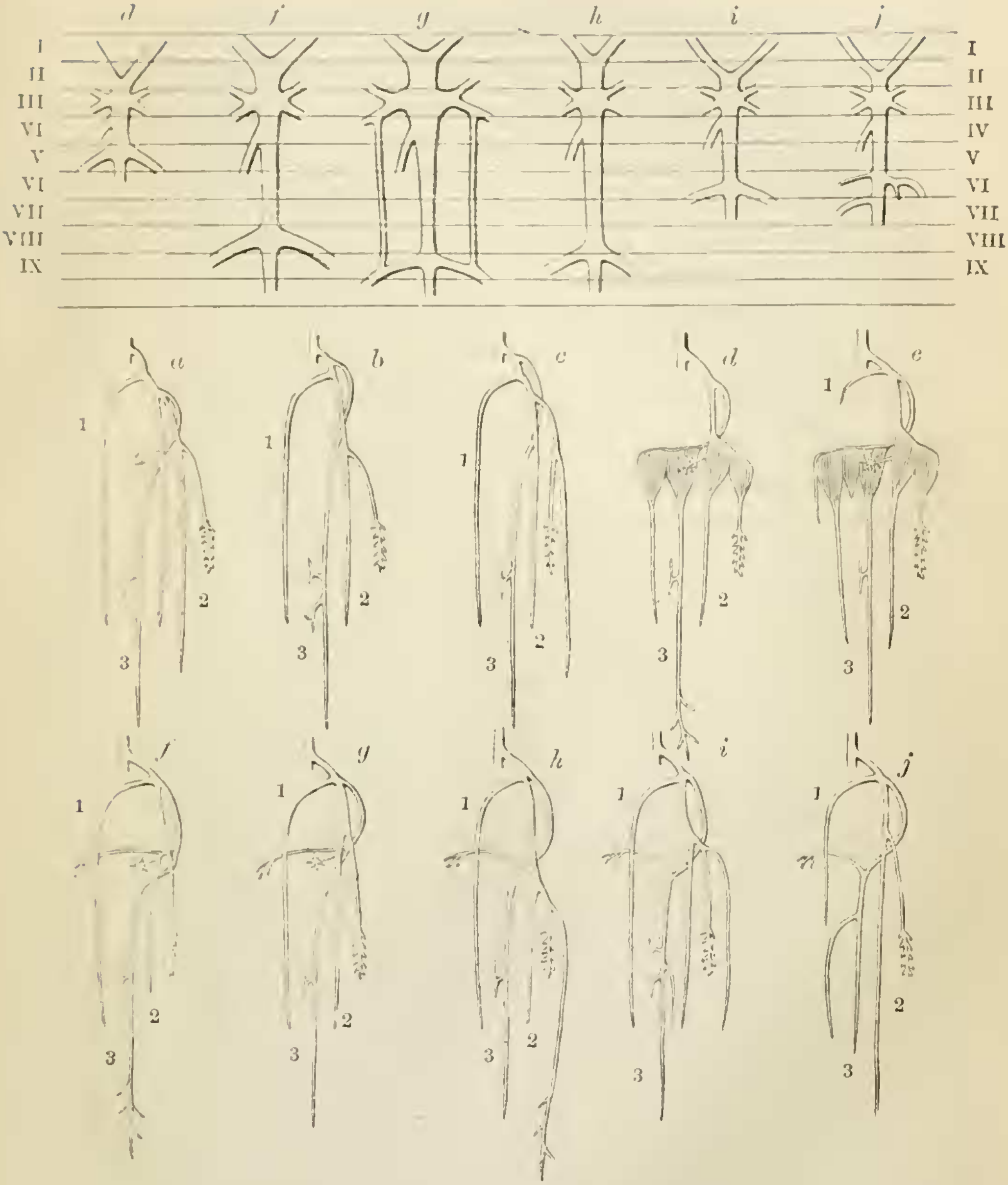


Fig. Q. Diagrams showing the arterial system of the scombroid fishes.

The upper row represents the anterior part of the visceral arterial system, showing the origin of efferent branchial arteries, coelinco-mesenteric artery, and cutaneous arteries. The Roman numerals denote the cardinal number of vertebrae. The other rows represent the visceral arterial system. *a*, *Scomber japonicus*; *b*, *Cybium niphonium*; *c*, *Sarda orientalis*; *d*, *Thunnus germo*; *e*, *Thunnus orientalis*; *f*, *Parathunnus mebachi*; *g*, *Neothunnus macropterus*; *h*, *Neothunnus rarus*; *i*, *Katsuwonus pelamis*; *j*, *Euthynnus yaito*.

branchial arteries, but a very small portion is sent ventralwards beneath the ventral aorta to form the hypobranchial artery, unappropriately named, which nourishes the heart, ventral fins, and the ventral carinales. In the Katsuwonidae this artery is divided into paired branches behind the ventral fins. A slender artery runs backwards just above the ventral aorta to nourish the heart. The artery is formed by the union of branches of downward efferent branchial arteries in the third gill-arches. A part of the blood in the efferent branchial arteries is conveyed anteriorly by the carotid arteries to the cephalic region, but the greater part of the blood is carried backwards by the dorsal aorta.

To the vertebral system arising from the dorsal aorta belong the renal arteries, subclavian, and in the case of the Plecostei, the cutaneous arteries. The subclavian arteries arise near the the root of the coeliaco-mesenteric artery in front of the pharyngeal muscles. They are short, and are soon divided into two branches, anterior and posterior. The posterior branch running obliquely backward becomes the subclavian or brachial artery for the pectoral fin. The artery is divided again into two or more, the exterior one of which goes to the extensor, the interior one to the retractor muscle of the pectoral fin. The segmental arteries are given off along the intermuscular bones, and also along neural and haemal spines. In the Scombridae and Cybiidae these segmental arteries are generally found in every other segment of the body. In the Plecostei, however, they are generally found in every segment. In the Cybiidae nearly all the precaudal hypaxial branches of the dorsal aorta give off short, dendritic renal arteries (fig. 6). In the Plecostei (figs. 4, 5) only horizontal segmental arteries are found in pairs in almost every segment of the body, and nourish the dark red portion of the lateral muscle, lying above the median horizontal network of the oblique tendons. Generally speaking the cutaneous arteries together with the median horizontal segmental arteries are the source of activity of plecostean fishes. In the Scombridae and Cybiidae these arteries are generally found in every other segment, but in the Plecostei they are found in every segment.

The cutaneous arterial system consists of one or two large trunks running near the lateral median line of the body, originating in the pectoral region, behind the pharyngeal muscle from the dorsal aorta. These arteries are nearly equally as large as the dorsal aorta itself. In *Thunnus* they originate in the segment of the fifth vertebra, in *Parathunnus* and *Neothunnus* in the segment of the eighth or ninth vertebra. ESCHRICHT observed that the dorsal aorta becomes abruptly slender after the ramification of these cutaneous arteries, in the following words:—"Nach dem Abgang der *arteriae axillares* wird die Aorta plötzlich mehr als um die Hälfte dünner im Durchmesser".

In the Thunnidae the cutaneous artery runs obliquely backward and dorsalward, passing behind the third (*Thunnus*) or fifth rib (*Parathunnus* and *Neothunnus*), and reaches the surface of the body before the intermuscular bone, attached above the root of the respective rib. Before reaching the surface of the body each artery is split into two equal branches, running dorsal and ventral to the lateral median line, nearly parallel to each other (fig. 3). They are united again in the caudal portion by a transverse commissure, and the commissure is again united to the dorsal aorta by a pair of horizontal segmental arteries (fig. 4). Each branch of the cutaneous arteries gives off, at the surface of the body, segmental arteries obliquely backwards along the borders of myotomes for some distance and then bends forwards. The dorsal branch sends dorsal segmental arteries only, and the ventral branch ventral segmental arteries only. These cutaneous segmental arteries send arterioles axially, along myocommata or straightly inward (fig. 3). Both dorsal and ventral cutaneous arteries, moreover, send one or two rows of very numerous parallel arterioles, quite close to each other. These arterioles run obliquely inward, along the boundary between the red and dark red portions of the lateral muscle. They are soon divided into several smaller canals and always run in association with similar venules making a membranous sheet investing and nourishing the dark red portion of the lateral muscle. The arterioles in the vascular sheet gradually unite again reduced in number at about midway between the surface and the axis of the body, and vanish in capillaries, so that the dark red portion of the lateral muscle is not entirely covered with fine bloodvessels and capillaries near the axial part. The vascular sheet is thick near the surface of the body, becoming gradually thin as it approaches the axis of the body. In the Plecostei, except *Euthynnus*, the cutaneous arteries always run on the axial and inner side of the accompanying veins. Generally the axial margin of the cutaneous vein partly covers or is at least apposed to the abaxial margin of the accompanying cutaneous artery; but in the blue-finned tuna from San Pedro, Cal., I found the axial margin of the cutaneous vein partly covered by the abaxial margin of the accompanying artery. In *Euthynnus* (all known species inclusive), however, the cutaneous artery lies on the abaxial side of the accompanying vein, and the axial margin of the cutaneous artery is partly covered by the abaxial margin of the accompanying vein (fig. 26). The distribution of smaller canals on the wall of the cutaneous arteries is variable in different species, and so far as I have examined, there are no two Japanese species of tunnies which have the arterioles distributed in the same way (figs. 20–24).

In *Thunnus germo* arterioles are distributed on the external axial side of the artery in two or more rows, and they run axially. In *Thunnus orientalis* arterioles are found on the internal side in one row, in *Parathunnus mebachi* in two rows, internal and external, in *Neothunnus macropterus* in one row or two indistinctly alternate rows on the side near the lateral median line of the body, and in *Neothunnus rarus* in one or two alternate rows at the middle of the abaxial side. In the Katsuwonidae, the cutaneous artery of the epaxial side would be homologous to both the epaxial and hypaxial branches of the cutaneous artery of the Thunnidae. The hypaxial cutaneous artery of the Katsuwonidae is remarkably short and slender, it generally originates in front of the epaxial artery, and takes a forward direction, and after passing through the kidney turns backward, it is situated in a more ventral position than the hypaxial branch of the cutaneous artery of the Thunnidae. In *Katsuwonus* the epaxial and hypaxial arteries are nearly equal and originate from a common lateral branch of the dorsal aorta, in the hind part of the segment of the sixth vertebra, just behind the pharyngeal muscle. The common lateral branch of the dorsal aorta is very short, horizontal. It is divided in the kidney into two canals or rather it is united to a gently curved canal, two limbs of which are turned backward. The epaxial limb passes beneath the first rib and then between the intermuscular bones of the second and third vertebrae, while the hypaxial limb passes over the first rib. In *Katsuwonus* the cutaneous artery is obviously narrower in calibre than the dorsal aorta, and the epaxial and hypaxial branches are much more separated from the lateral median line than in tunnies. The arterioles from these branches are given off at the surface of the body, between myotomes on both sides of each branch, dorsal and ventral. Those numerous arterioles nourishing the dark red portion of the lateral muscle run axially. In *Euthynnus* and *Auxis* there are two pairs of cutaneous arteries originating from two different points. The anterior pair is smaller, homologous to the hypaxial limb of the cutaneous artery of *Katsuwonus*, and is given off from the body segment of the sixth vertebra. The artery takes a more or less forward direction, passes through the kidney and then turns backwards. The artery has no relation with the dark red muscle. The posterior pair is very thick, nearly as thick as the dorsal aorta or a little thicker than it, probably homologous to the whole cutaneous artery of the Thunnidae. The posterior pair of cutaneous arteries takes an obliquely upward and backward direction, and makes its appearance at the surface of the body, between the intermuscular bones of the fourth and fifth vertebrae. The artery runs a little above the lateral median line, and seems to vanish in the caudal part. The cutaneous artery sends off segmental branches to the surface of the body, both dorsal and ventralwards, and axially very numerous arterioles to the dark red portion of the lateral muscle. These arterioles are arranged in two diverging sheets to invest the dark red portion of the lateral muscle. In a rare abnormal case, I found the posterior cutaneous artery joined to the anterior cutaneous artery, but in such cases the abnormality is found in one side of the body only.

In the Plecostei subspinal vascular plexus or the kurochiai, the vascular plexus in the haemal canal, deserve attention. In *Neothunnus* vertical arterioles originate as short parallel numerous vessels from the dorsal aorta in the same way as the accompanying veunles originate from the cardinal vein and these together make a black red rod as thick as a thumb. These numerous arterioles unite again to two pairs of segmental arteries in each body-segment, one along the intermuscular bone, the other along the neural spine. In the Katsuwonidae the subspinal vascular plexus does not lie just beneath the vertebral column but is more or less separated from the latter. In *Euthynnus* and *Auxis* (fig. 2) the dorsal aorta is so remarkably separated from the vertebral column that the kurochiai is bent like a bow. In *Auxis* the arterioles are few in number and the subspinal vascular plexus is much degenerated. The oblique segmental arteries from the dorsal aorta nourish the dark red portion of the lateral muscle from the axial side.

The coeliaco-mesenteric artery (fig. Q) is a chief unpaired visceral artery originating just before the right pharyngeal muscle. The artery passes the right side of the muscle and is divided into three branches. I shall distinguish them as the first, second and third branch respectively; numbering from the left dorsal side gradually to the right ventral side. The fate or destination of these branches are very different in different species, especially in the Plecostei. The first branch is short and simple, but the other branches are large and branching. In the Scombridae and Cybiidae the first branch nourishes the oesophagus and the left dorsal side of the stomach. The second branch is divided into two branchlets, one of which nourishes the right dorsal side of the stomach and the air-bladder, when it is present, and the other the spleen and intestine. The third branch the ventral side of the stomach and the pyloric coeca. In *Thunnus* the first branch is abortive, and nourishes the oesophagus only or is entirely absent. The second branch is divided into short parallel numerous arterioles in the right lobe of the liver and then reunited to about three branchlets, one to the air-bladder, another to the right dorsal side of the stomach, and the remaining to the spleen, pyloric coeca, and intestine. The third branch runs along the abaxial side of the liver and is also divided into numerous arterioles in the middle and left lobes of the liver. These arterioles are reunited into principal canals, one nourishing the left dorsal side of the stomach, and the other the ventral side of the stomach, pyloric coeca, etc. In *Thunnus orientalis* the third branch is subdivided into two before splitting into numerous arterioles. In *Parathunnus* the first branch nourishes the oesophagus and the left dorsal side of the stomach as in the Scombridae and Cybiidae. The second branch nourishes the air-bladder, right dorsal side of the stomach, spleen, and intestine; while the third branch is divided into two branchlets, one into the liver the other to the ventral side of the stomach, pyloric coeca, and intestine. In *Neothunnus* nearly the same as in *Parathunnus*, but the artery to the liver is much more degenerated. In *Katsuwonus* the first branch nourishes the oesophagus, left dorsal side of the stomach, but in *Euthynnus* and *Auxis* it is very short, slender, and nourishes the oesophagus only. The second branch nourishes the right dorsal side of the stomach, spleen, and intestine, while the third branch nourishes the liver, ventral side of the stomach, and intestine. In the Katsuwonidae the hepatic artery runs more or less forward near the root.

RENAL ORGANS.

The kidneys are well developed in the Scombridae and Cybiidae. They are paired, very thick at the sides of the pharyngeal muscles, but behind these muscles they are blended together and become gradually narrow towards the caudal portion. In *Sarda orientalis* the kidneys are united before the pharyngeal muscles. The organs reach the otic region of the cranium, then run along the ventral side of the vertebral column, between the base of ribs, and lie above the peritoneal membrane of the air-bladder, when it is present. The organs often reach the anus posteriorly. They never enter the haemal canal. The kidneys are reddish in colour, which become paler in preserved specimens and minute black spots may be seen scattered all over them. These are due to the pigment cells accumulated in glomerules. In the Plecostei the kidneys are generally concentrated in the pectoral region. This is especially the case in primitive forms of the order, for instance, in *Thunnus germo* and *Th. orientalis* the kidneys are more or less ring-shaped, as the organ of one side is connected to the organ of the other side at the anterior and posterior sides of the pharyngeal muscles. In these forms of tunnies a slender kidney-like organ enters the haemal canal and runs more or less posteriorly, just below the vertebral column. The organ is thickened at the root of each haemal arch. In other forms of tunnies the kidneys are elongated backward along the dorsal wall of the abdominal cavity. In the Katsuwonidae the oblong space for the passage of the pharyngeal muscles is divided by a median longitudinal bridge of kidneys. The seemingly renal organs in the haemal canal are detached from the main body in *Katsuwonus*. In *Auxis* the renal organ is not found in the haemal canal. It is not developed in the cephalic region, and its posterior part is divided into two long slender bodies, running on both sides of the posterior cardinal vein.

In the Scombridae the ureters are nearly separate from each other, in the Cybiidae they are separate for the most part, but are united to a short median duct, before opening to the urinary bladder. In the Thunnidae they are united to a long median duct, but they are nearly separate again in the Katsuwonidae. In *Thunnus germo* two ureters meet nearly in a transverse line, perpendicular to the median united duct, and at the middle of the former there is a short median septum. In *Thunnus orientalis* the two ureters meet in a figure like U, and in the other forms of the Japanese tunnies they meet like the figure V. In *Katsuwonus* the two ureters run quite near by in the posterior slender part of the kidneys, and finally unite to a median canal of some length. In *Euthynnus* and *Auxis* the two ureters are nearly separate.

The urinary bladder is variable in size, form and position. Generally it is small and lies behind the peritoneum, but in *Acanthocybium*, *Neothunnus*, and *Auxis* the bladder is large or much elongated and is found in the abdominal cavity, suspended in the mesentery or between the two genital glands and above the rectum.

REPRODUCTIVE SYSTEM.

In the scombroid fishes the generative organs are paired, large, and elongated sacs on the roof of the abdominal cavity, suspended in a fold of the peritoneum, and extend along almost the whole length of the cavity. The organs on both sides are symmetrical, nearly equal to each other in form and size. In *Auxis* the generative organs, both male and female, extend backwards along the side of the anal fin. This backward extension is not so marked as in the case of the female flatfish, but its cause is the same—the narrowness of the abdominal cavity. In scombroid fishes the genital glands generally seem to ripen in the third year of growth, that is when the fish is two years old.

The testes have trenchant edges, hence more or less lanceolate in cross-section, and when ripe, milky white to light yellowish in colour. The ovaries are fusiform, more or less roundish in cross-section, and yellowish in colour, and greater in volume than the testis. In tunnies the gonads grow very large, attaining several kg. in weight. As the eggs in them are minute as in other fishes, their number is no doubt enormously large.

Scombroid fishes generally spawn in the warm season, and in the open sea. So far as I know, *Scomber japonicus*, *Cybium niphonium*, and *C. koreanum* are the only species which spawn in our bays and inland seas. Spawned eggs and larvae of the plecostean fishes are still unknown.

The generative organs of both sides coalesce near the hind end, and the lumen in them unite to a short and wide duct, which opens as a transverse slit on a papilla, behind the anus.

Biology and Ecology.

HABIT.

The scombroid fishes are said to be pelagic, but only the fishes of the Plecostei are truly pelagic. The mackerels, *Scomber* and *Rastrelliger*, live in littoral waters, and most seerfishes too. The tunnies and bonitos, however, feed, spawn, and grow in the open sea.

Scombroid fishes generally swim to the shallower strata of water at night, and return to the deeper layer in day-time, probably following the movement of the plankton, and also that of those animals which feed on plankton. Thus the twilight is the best time for fishing these fishes.

Scombroid fishes swim near the surface of the sea, in and after the spawning season. These fishes are alert and very difficult to catch. They approach the shore in warm seasons, and retire to deeper layers of water in off-shore grounds in cold seasons. When a southerly wind blows, the common tunny comes near the surface of the sea, and also approaches the shore. Until recently, no drifters for the tunny were found out on the sea, when other winds prevailed. Lightning and the sound of thunder are said to frighten tunnies and bonitos, driving them into deeper strata of the water.

Tunnies are often said to resort to the neighborhood of deep rocky banks, rising to ca 200 m below the surface. Especially *Parathunnus mebachi* swim in rather deep layers of water, about one hundred metres below the surface. *Thunnus germo* is said to descend to a depth of ca 80 m, while the other tunnies can descend to a depth of ca 50 m. In summer, schools of *Thunnus orientalis* and *Neothunnus macropterus* sometimes swim with the tips of the dorsal fins and the anal out of the water. Bonitos swim quite near the surface of the sea, and seldom descend below forty metres.

Scombroid fishes often leap out of the water, or show the posterior portion of their body, especially when they are feeding. *Parathunnus mebachi* is said to have a peculiar habit of leaping out of the water at day-break.

Scombroid fishes very soon succumb after a violent convulsion, when caught and taken out of the water. They are very difficult to keep alive, except the common mackerel, as they dart against the fence, when confined in a narrow space, and they can not exist in water of low salinity. Tunnies desert littoral grounds after a heavy rain, and approach the coast in summer, after a long draught. In the Bay of Yenoura, at the foot of Mount Fuji, tunnies are sometimes kept alive, surrounded by a wall of strong netting near the shore.

Pelagic scombroid fishes often crowd under drift wood or algae, or follow whales or vessels. *Acanthocybium solanderi* is attracted to bundles of wood moored at the surface of the sea, purposely devised by fishermen.

Fishes of the Cybiidae are voracious and audacious. They strive to get out of a pound-net, pushing their head through the meshes at the bottom at night, though in the day-time they are afraid to pass through meshes.

Plecostean fishes are especially timid, as was observed by previous writers, and do not dare to pass through the meshes of a net, until they are confined in a narrow space, though the meshes are wide, expanded, and large enough to be passed freely. Neither do they enter a dark cove, nor approach very near a rocky precipitous wall. When some fish are entangled in a net, and are struggling to escape, the remaining fish of the school are scared away. It is, moreover, told that they are terrified and disappear when they see blood. Thus the throwing out of bilge-water, contaminated with blood, is not permitted at the fishing ground, and with the same reason long lines of sharks are considered to be disadvantageous to bonito fishing, as sharks shed blood when hooked.

Generally the male fish come first, in the middle of the fishing season the number of both sexes is nearly equal, and at the end of the season the female fish predominate.

The habits of the scombroid fishes are often influenced by tides. Mackerels often float towards the surface of the sea, shortly after the flood-tide. Some seerfishes are said to be very active in the ebb-tide, and *Gymnosarda nuda* is said to bite hooks well, when there is no tidal current. Some tunnies are said to resort to the shore with the flood-tide.

Bonitos, except *Euthynnus yaito*, are said to be very clever in making a school of small fish very dense, by swimming round the school of the victims, and devouring stray or forelorn individuals gradually. On the contrary, tunnies and seerfishes swim into a school of victims, and disperse them. The feeding of a fish seems not always the same throughout the year. The striped bonito is said to decline to take bait in certain seasons, generally in mid-summer.

FOOD.

Fish belonging to the genus *Rastrelliger* seem to feed exclusively on plankton, chiefly copepods. *Scomber* is also a plankton-feeder, but its food differs in different seasons and localities. In bays the fish is omnivorous, and feeds near the bottom; but in the open sea it seems to feed near the surface. Fishes of the Cybiidae are voracious, and feed chiefly on surface-swimming and school-making fishes, such as sardines, anchovies, saurels, mackerels, sand-eels, &c.

Tunnies are also voracious, and most of them feed chiefly on plankton in the open sea. So far as I know, *Neothunnus rarus* seems to be the only species which feeds near or in littoral waters, and chiefly on fishes of moderate size. When tunnies devour fish of somewhat large size, they break their vertebral column near the neck or the tail, probably with their strong jaws, most likely to prevent movement of the engulfed fish in the stomach. Once I found a specimen of *Lepidopus*, about two metres in length, in the stomach of a tunny. It was found bent several times in the stomach. A full-grown tunny can swallow bonitos or young tunnies under 40 cm in length. The smallest animal found in the stomach of a full-grown tunny measured about 5 mm. in length. Judging from the position of food in the stomach, we understand or rather imagine that tunnies swallow fish sometimes from the head, and sometimes from the tail. Tunnies feed on living animals, but they are enticed by deceased or preserved baits as well, and even to artificial batis when they are moving in water. The food of bonitos is nearly the same as that of tunnies. However, bonitos can not swallow large animals as tunnies do. Many interesting forms of the plankton and immature fish, etc. may be found in the stomach of tunnies and bonitos. I have obtained two fine specimens of *Mola mola*, very large phyllosoma of *Scyllarus*, immature specimens of free-swimming stages of *Scyllarus* and *Panulirus*, *Onychoteuthis*, a great many specimens of *Watasenia scintillans* from the mouth of Tokyo Bay, several species of *Pteraclis*, *Acanthurus* (immature), *Chaetodon* (immature), *Maurolicus*, *Argylopelecus*, *Holocentrum*, *Ostracion*, *Caesio*, *Exocoetus*, *Sergestes*, *Acanthephyra*, different kinds of Heteropoda and Pteropoda.

Scombroid fishes feed on swimming animals, and do not prey at the bottom, nor at a wall nearly perpendicular. They swallow the food, darting quickly towards it, and swim away more or less downwards, therefore they are forced to make a large circuit if they intend to take food again near the same spot as before. Generally they hesitate to swallow food, when it is too large for a mouthful. As a rule they pursue food into shallower strata than those they are accustomed to. While feeding, fishes in a school swim in different directions as they like. A fish which has taken plenty of natural food, is easier enticed to baited hooks than one with an empty stomach. This may bs explained by the fact that the fish become frenzied from competition when feeding in a school, and bite any object, suspended or moving in the water, but when they are not feeding they are rather shy and suspicious, and thus do not easily bite baited hooks. When tunnies bite baited hooks, they swim downward at once very quickly, about 200 m, more or less obliquely, so that tunny-fishermen are provided with a strong line, longer than 200 m.

DEVELOPMENT AND GROWTH.

The development of mackerels and certain seerfishes can be studied; but that of the plecostean fishes is very difficult to study, as these fishes do not approach the land, at least in the spawning season. I have not yet succeeded in obtaining these fishes with mature reproductive elements. Consequently the larval and postlarval fishes of the Plecostei are still unknown. Two small specimens described and figured by LÜTKEN (53) and identified to be the young of *Thunnus alalonga* are the smallest examples, so far as I know; but most probably they do not belong to the Plecostei, as the foremost spine of the first dorsal is remarkably shorter than succeeding spines. They would most probably be immature forms of the Cybiidae, as the jaws are long and the teeth large. An immature specimen caught in a tow-net during the Challenger Expedition, between the Admiralty Islands and Japan, and described by GÜNTHER (32) is probably a plecostean fish.

In May, immature fishes of *Scomber japonicus* about 45 mm in length are caught together with colourless fries of the sardine, anchovy, etc. near the coast on the Pacific side. These immature fishes have slenderer body, rounded snout, teeth in the lower jaw in two rows, but remarkably few in number. In September they grow to the length of about 12 cm, in October 15 cm, and when one year old to 18 cm. I am

Fig. R. *Scomber japonicus.* Nat. size.

inclined to believe that the young fish, about 27 cm long are two years old, and young ones about 35 cm are three years old, and sexually mature. Thus the growth of our common mackerel seems to be nearly the same as that of *Scomber scombrus* of the Atlantic. However, this rate of growth is slow compared with that of other scombroid fishes, and needs confirmation.

So far as I know, eggs of the scombroid fishes are pelagic, spherical, and each egg is provided with a pretty large oil-globule. There are very little distinctive characters in eggs of different species. Eggs of *Cybium niphonium* are very large, the largest among the pelagic eggs, found in the Inland Sea in spring.

In 1920 I found a larva of *Cybium niphonium*, 8 mm in length, among a bunch of immature forms of various fishes from the bunt of a seine, hauled to catch the adult of that species, on June 7th, in Kagawa-ken. The larva has a very long snout, powerful jaws with large teeth, preopercle with three spines, very short but broad precaudal portion, pigment spots on the head and along the ventral median line of the caudal portion. An immature fish of 33 mm in length has a larger head and broader body than the adult. The preopercle is armed with about four spines. The pectoral is small and rounded, and the posterior portion of the second dorsal and anal begin to be separated to finlets. In this specimen the precaudal portion was elongated to a nearly similar length as the caudal. The first dorsal is higher than the second. An immature fish of 100 mm, caught late in July, 1914, has a still broader body than the preceding. The first dorsal is lower than the second dorsal, and the caudal is much developed. The general appearance is quite similar to that of the adult. The colour markings are however wanting. In the immature fish below this size

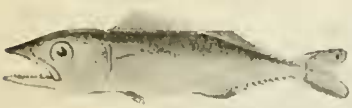


Fig. S. *Cybium niphonium* (immature). 4/3.

Fig. T. *Cybium niphonium* (immature). Nat. size.

the outer margin of the first dorsal gradually descends and its spines are 20 or 21 in number instead of 19 in the later stages, due to the depression of posterior spines. In October the immature fish grows to a length of ca 27 cm, and attains all the specific characters of the adult. As the fish grows the spines in the fin become longer, especially at the posterior part. One year old fish is ca 50 cm long and immature, while a two year old fish is about one metre and is mature.

Cybium koreanum spawns in June and its immature fish is about 24 cm. in September. It has a larger head, second dorsal and anal lower than the adult, and a few, scarcely visible markings in a row, just below the lateral line in the precaudal region.

An immature fish of *Cybium commerson*, 13 cm. long, was caught on July 27, 1916 near Keelung, Taiwan. It has a larger head, remarkably broader body, shorter snout, and larger eyes than the adult. The first dorsal is higher and its hind portion remains colourless. About ten oblong markings are found at the back. They scarcely pass down the lateral line. A little larger specimen in the Museum at Taihoku measures 22 cm in length, and has larger eyes. The colour markings are elongated downwards, but they are not continuous, more or less bead-like, and new markings are added between the old.

An immature fish of *Sarda orientalis*, 17 cm in the total length, was caught at the end of April, 1922, in a large dip net, called "bōke-ami," in the Harbour of Kushimoto, Wakayama-ken. The net was used at night under an artificial light to catch fries of the mackerel. The immature fish of *Sarda* has about twelve transverse bands. In each of these bands we find about six

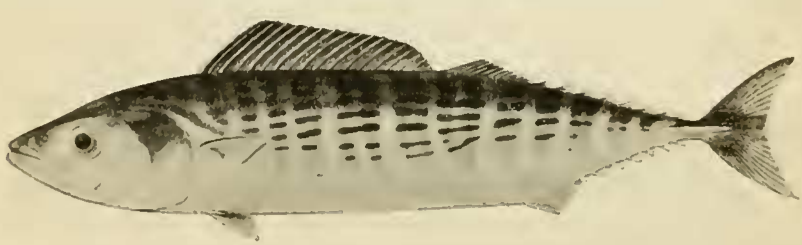


Fig. U. *Sarda orientalis* (immature). 2/3.

longitudinal bands, which ascend more or less backward. Pectorals, second dorsal, and anal are very small. In September, 1900, a little larger immature fish, 23 cm in length, was caught in a ground seine on the east coast of

Aomori-ken. This specimen is nearly the same as the preceding one, but it is a little broader.

An immature fish of *Acanthocybium solandri*, 27 cm. in the total length, was caught off Daiōsaki, Miye-ken, in September 1917. It has about twenty transverse bands. Those in the precaudal region fade away near the ventral median line, but in the caudal region they are manifest from the back to the ventral median line.

The growth of tunnies seems to be very rapid. The common tunny, *Thunnus orientalis*, most probably reaches maturity in the third year of age. *Thunnus orientalis*, ca 22 cm in the total length, is the smallest specimen I have seen. It has ten to fifteen faint transverse bands which fade toward the ventral median line. These transverse bands are divided into two at the ventral part. Such small individuals are found in August and in September. Some of them grow to a length of 30 cm or more. By next spring they grow to a length of ca 60 cm (fig. 43). When two years old they are about one metre in length and eleven kg. in weight. Three years old fish is considered to weigh about fifteen kg. The growth of *Thunnus germo* and *Neothunnus*

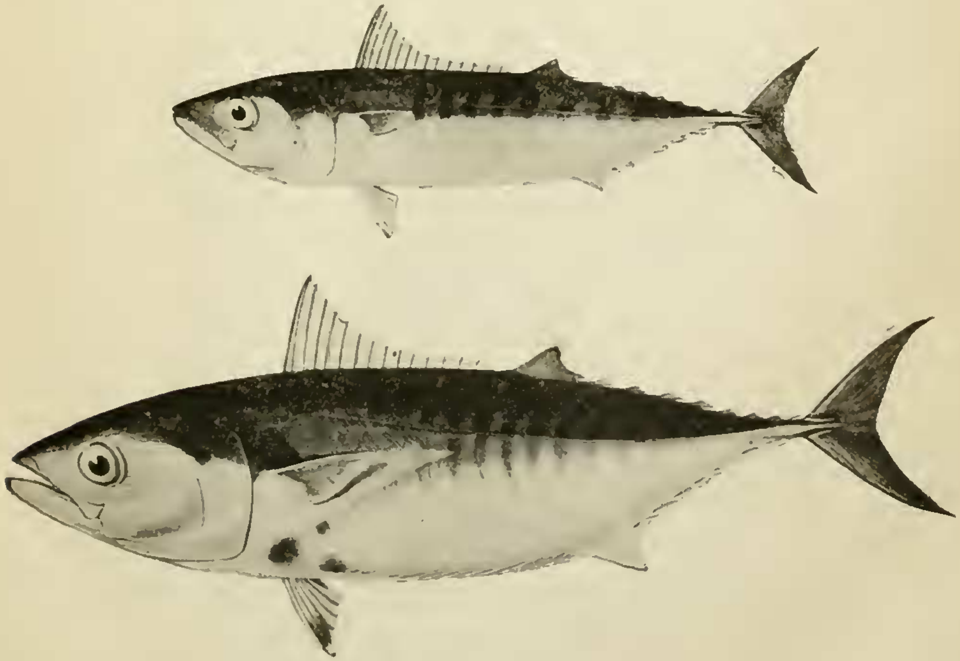


Fig. V. *Euthynnus yaito* (immature). 2/3.

macropterus in the first and second years seems to be nearly the same as that of the common tunny; but in the young form of *Thunnus germo* reticulating longitudinal bands are found, instead of transverse bands.

The smallest specimen of *Katsuwonus pelamis* in my collection is 21 cm. in the total length. It has a slenderer body than the adult, three dark oblique markings at the back of the caudal portion, and one faint longitudinal band under the lateral line. This specimen was caught in August, 1916, at Okinawa-ken, and seems to have been a fish hatched during the same year. The smallest specimens of *Euthynnus yaito* in my possession are 13 cm in the total length. One of them was sent by Mr. GOBEE. It was collected by the SS "Gier" in November, 1907. The other specimen was collected near Keelung, Taiwan, in 1919. They are very slender and have eight or more transverse bands on the side. These bands are nearly vertical and fade toward the ventral median line. When they grow to a total length of 19 cm the body becomes very broad, the thoracic spots appear, the bands gradually disappear from the ventral part, and the dorsal part of the bands becomes oblique.

Mr. S. TOMINAGA sent me several immature specimens of *Auxis maru*, which he obtained from the stomach of striped bonitos, caught off Awakunijima, Okinawa-ken (Ryukyu). They measure 11–17 cm. in length. The largest specimen is nearly the same form as the adult, but the specimens, 11–13 cm in length, are remarkably slender. The skin is more or less damaged by gastric juice, and the markings are not found in these small specimens, but in the largest specimen, there seem to be some transverse bands. They were collected on July 10, 1921.

LOCOMOTION.

About the locomotion of the fishes of the Scombridae and Cybiidae there is nothing new or peculiar. It is quite similar to that of other teleosts. Swift and unceasing locomotion is, however, characteristic of the Plecostei. It is impossible for fishing boats, running about 10 knots an hour, to accompany a school of the striped bonito in progress, so that fishermen throw out live baits to attract and thus to retard or stop the progress of the school. Plecostean fish scarcely bend their body in locomotion, except the caudal peduncle, as will easily be understood from the form and construction of the vertebral column, it can not be easily bent. The tail-fin is rigid and lunate, its quick and powerful strokes can be understood from the quick and high pitched sound produced by the fish in its death-struggle on the deck of a boat when caught. If a landing hook is driven by mistake into the caudal peduncle of a tunny, we can not hold it, as the hands become paralyzed from the violent convulsion of the muscles. Neither can we hold, even for a few seconds, a landing hook driven accidentally into a tunny swimming away from our boat. Really bonitos and tunnies swim like meteors. The troll-line for tunnies as well as the line attached to a harpoon-head used in tunny-fishing require a reserve of at least 200 m, though the troll-line for a seerfish has a reserve of only 30 m or often none at all.

MIGRATION.

The scombroid fishes, especially the plecosteans are good swimmers, and as they are voracious, they are forced to swim about incessantly in search of food. Like many other fishes, scombroid fishes generally swim in shallower strata of water at night, and seek the deeper strata in day-time. They migrate more or less according to the change of temperature. In the cold season they seek lower latitudes, in summer they go further north; but *Cybium commerson* seems to be exceptional, visiting the western coast of Hondo in the Japan Sea in winter only. The migration of the striped bonito is also remarkable. On the Pacific coast the fish migrate with the warm current and in summer they reach the southeastern coast of Hokkaido and remain there till autumn. In their northerly migration they approach the coast, but in moving south they swim off-shore. In the Japan Sea they take a quite different course, approaching the coast in their southerly migration in the cold season. The migration of *Thunnus orientalis* and *Th. germo* in the Pacific coast is nearly the same as that of the striped bonito. *Thunnus orientalis* in the Japan Sea approaches the coast in going north, in early summer.

Generally speaking of scombroid fishes, large and old are caught at the beginning of the fishing season, while at the end of the season only young and small ones are found.

DISTRIBUTION.

Scombroid fishes are generally widely distributed, and many of them are really cosmopolitan; but some of them are confined to limited districts. For instance *Cybium koreanum* and *Neothunnus rarus* have restricted distribution. Generally speaking the mackerels and seerfishes which have a wider range in vertical distribution have a narrower range in horizontal distribution.

Scomber japonicus is very widely distributed. It is said to occur in the Pacific as well as in the Atlantic. In the Pacific it is found on the Asiatic as well as on the American coasts. However, the fish is not found round the oceanic islands, such as the Ryukyu Islands, Ogasawara Islands, and South Sea Mandates. Adult mackerels migrate in summer to shallow waters, ca 20 m deep in a bay, but retire in autumn to deeper waters of 40–100 m, and in winter to off-shore banks, ca 200 m in depth. Generally mackerels are not found in deeper strata of water than ca 100 m. In waters within the 100 m line of depth, mackerels are found 1–4 m above the bottom. They come near the surface in the evening, and may be attracted to shallow strata within 40 m below the surface.

Rastrelliger is confined to the Ryukyu Islands in our country, but it is widely distributed in the tropical seas.

In the Cybiidae, *Grammatorcynus* is found only in Ryukyu Islands in our country, but is widely distributed in the tropical region of the Indo-Pacific. *Cybium niphonium* is found in the littoral waters of Japan, Korea, and China. *Cybium koreanum* is restricted to the west coast of Korea. It is remarkable that this species ascends the brackish part of rivers. *Cybium commerson* is regularly caught, though in small numbers, near Senzaki, Yamaguchi-ken, in autumn and winter. This species is caught in abundance in Formosa in spring. *Cybium guttatum* is found in our waters only in Formosa. *Cybium chinense* is found in Japan and China, frequently near the Korean Channel; but they are rather rare in other regions. *Acanthyocybium solandri* is a pelagic species, nomadic in habit, and inhabiting warm seas. It is found at the mouth of Tokyo Bay, in the east, and in the south western part of the Japan Sea. *Sarda orientalis* is abundant in Kyushyu, but it may be found in Aomori-ken in the north, both off the Pacific and the Japan Sea coasts. None have been found in Formosan waters. I do not know whether the Indian species of *Sarda* is identical with our species or not. The Hawaiian species looks quite similar to our species in external characters; but minute examination is necessary for identification.

So far as I know the plecostean fishes are most rich in number of species in our waters. Among our tunnies, *Thunnus orientalis* is rather widely distributed. *Neothunnus rarus* is found only in Kyushyu and the south-western part of the Japan Sea. In the Japan Sea we find only three species of tunny;—*Thunnus orientalis*, *Neothunnus macropterus*, and *Neothunnus rarus*. The latter two species, however, are very few in number, and there is no regular fishing for them. All the species of tunnies found in the Japan Sea live near the surface and approach the coast. The tunnies inhabiting off-shore grounds and descending into rather deep strata of water have not yet been found in the Japan Sea. This is most probably due to the fact that the temperature of the sea is too cold for these species. Bonitos are also found in the Japan Sea; but rather few in number, and *Euthynnus yaito* is very rare.

The scombroid fishes with the air-bladder have generally a wider range of vertical distribution than those without it. The latter group of fish is often restricted to the surface of the water. Or they are near the surface in some seasons, and descend to deeper layers of the sea in other seasons. They can not change their abode suddenly, but when the change is gradual they can endure it. Most scombroid fishes swim in shallow strata of water, but tunnies generally, especially *Parathunnus mebachi*, are found in deeper strata of water than bonitos. Bonitos and voracious species of the Cybiidae frequent the surface of the sea and are readily attracted to artificial baits. These fishes are rarely found in deeper strata than about 80 m.

The scombroid fishes are found in warm seas, the majority of them belonging to the tropical and subtropical regions, and most of them are very widely distributed. They swim very fast in search of prey, and many of them have their own blood-temperature as higher animals. Our common mackerel and the striped bonito are cosmopolitan species. The long-finned tunny (*Thunnus germo*) and *Acanthocybium solandri*, too, seem to be widely distributed, though a critical determination of the species from different parts of the world has not yet been made. The following tables illustrate the distribution of scombroid fishes in our waters and adjacent regions.

	Pacific Ocean										Japan Sea						Yellow Sea		Eastern China Sea			
	South Sea Islands (Japanese Mandates)	Taiwan (Formosa)	Ryukyu Islands	Ogasawara Islands	Kyushyu	Inland Sea	Southern Coast of Shikoku	Middle Hondo	North Hondo	Hokkaido	Karafuto	Hokkaido	North Hondo	Middle Hondo	West Hondo	Chosen (Korea)	Chosen	South Manchuria	China	Kyushyu	Ryukyu Islands	Taiwan (Formosa)
Scomber japonicus					×	×	×	×	×	×	×	×	×	×	×	×			×	×		×
Rastrelliger chrysozonus	×		×																			
Grammatorcynus bilineatus	×		×																			
Acanthocybium solandri			×	×	×		×	×								×	×					
Cybium commerson															×	×			×			×
Cybium niphonium					×	×	×	×	×	×			×	×	×	×	×	×		×		
Cybium chinense					×		×	×					×	×	×	×	×			×		
Cybium koreanum																	×					
Cybium guttatum																			×			×
Sarda orientalis					×		×	×	×					×	×					×	?	
Gymnosarda nuda		×	×	×																		
Thunnus germo			×	×	×		×	×	×	×										×	?	
Thunnus orientalis					×		×	×	×	×	×	×	×	×	×	×				×		
Parathunnus mebachi		×	×	×	×		×	×														
Neothunnus macropterus	×	×	×	×	×		×	×				×	×	×	×					×	?	
Neothunnus rarus					×										×					×		
Katsuwonus pelamis		×	×	×	×		×	×	×	×				×	×					×	×	×
Euthynnus yaito		×	×		×		×	×												×	×	×
Auxis hira			×		×	×	×	×	×	×		×	×	×	×					×	×	×
Auxis maru			×		×	×	×	×	×	×		×	×	×	×	×	×			×	×	×

Table showing the temperature of water in which scombroid fishes are found.

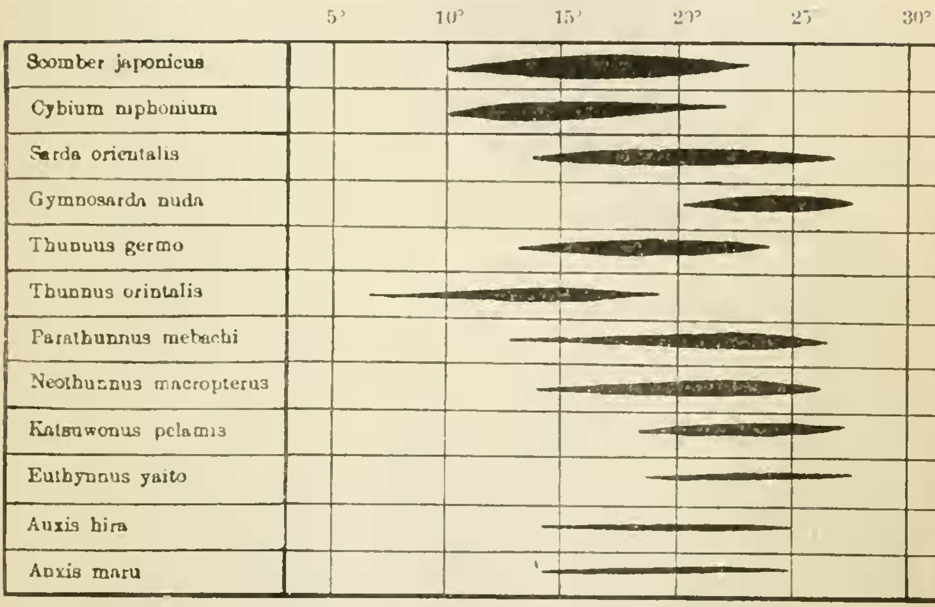
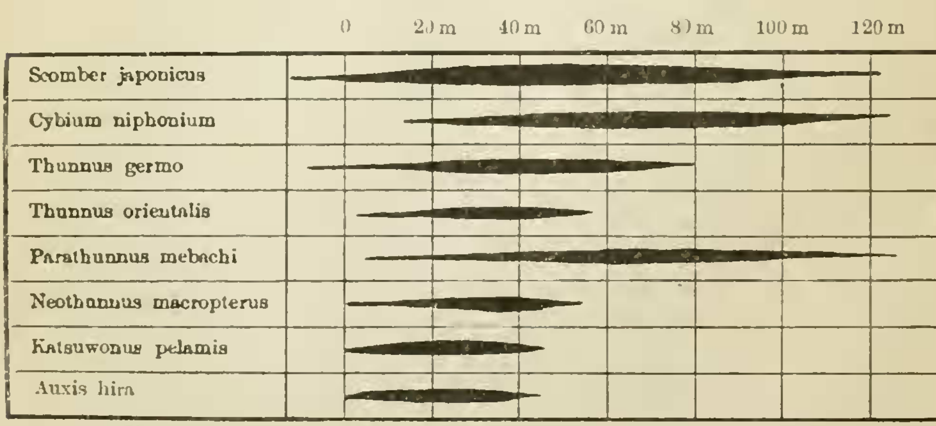


Table showing the vertical distribution of scombroid fishes.



The salinity of the water, most suitable for our scombroid fishes, differs very greatly for different species. Generally speaking fishes of the Scombridae and Cybiidae are adapted to water of lower density, 1.022—1.025, while plecostean fishes prefer water of higher density, 1.025—1.027. *Cybium koreanum* can withstand water of very low density. Of the Katsuwonidae, species of *Auxis* are sometimes found in littoral waters of low density.

ENEMIES AND PARASITES.

The gigantic species of the scombroid fishes have few enemies. Their most dreaded enemies are dolphins, especially the killer. Killers often await the passage of large schools of tunnies in a strait, such as Tsugaru Strait, and attack them furiously. Favourite resorts of killers in the strait are near Cape Ōma and Cape Tappi. Small species and immature forms, however, have many enemies—seals, dolphins, spear-fishes, the sword-fish, sharks, and larger forms of their own or allied species. When we find dolphins in places, where mackerel fishing is actually carried on, the mackerels very soon desert the ground, and do not come back for some days after.

External parasites are mostly copepods and trematods. They are found on the upper surface of the pectoral fin, the inner side of the opercle, gill-lamellae, in the nasal cavity, the mouth cavity, etc. These parasites are, as a rule, not numerous; but sometimes copepods are found in large batches. The *Octocotyle* is a minute parasite found among the gill-lamellae of *Scomber japonicus*, but the *Hexacotyle* is large and is found among the gill-lamellae of *Parathunnus mebachi*. *Tristomum* lives in the nasal cavity of tunnies.

Internal parasites are chiefly trematods and nematods, living in alimentary canal, circulatory system, muscles, tissues of the viscera, etc. Species of *Distoma* use *Acanthocybium*, tunnies, and bonitos as hosts. *Rhynchobothrium* is found in the flesh of *Katsuwonus pelamis* rather abundantly in summer. A species of the Filariadae generally inhabits the superficial dark red muscle of *Parathunnus mebachi*. The parasite changes the colour of the muscle, which becomes more or less yellowish. Once I found a very long nematod in the cutaneous artery of *Euthynnus yaito*. Often a species of nematod is found in the dorsal aorta of *Neothunnus macropterus*; the parasite causes the tissue of the canal to become thick and tough, giving it at the same time a yellowish tint.

FISHERY.

Fishing of the scombroid fishes has been pursued in our islands since the stone age. Bones of these fishes have been found in shell-mounds in different localities of our empire, as I have said already in a paper on the prehistoric fishing of our country (42). Bones of *Thunnus orientalis* are most abundant, and those of *Katsuwonus pelamis* and *Scomber japonicus* are frequently met with, but those of *Auxis* and *Cybium niphonium* are rather rare. After the publication of the paper, I obtained through the kindness of Mr. GENSHICHI YENDO a spear-head, 214 mm long, lacking a barb, carved from a caudal fin-ray of a tunny. He collected it from a shell-mound of Miyagi-ken. A large caudal vertebra, recently discovered by Mr. AKIRA MATSUMURA in a shell-mound of Ogido, Ryukyu, belongs most probably to a species of *Gymnosarda*. A few vertebrae of *Euthynnus yaito* were also taken from a shell-mound of Iha, Ryukyu, by Prince KASHIWA ŌYAMA.

In some poems composed in the period of Tempyō-Shōhō (749–756) and cited in the "Manyōshyu", we learn that the tunny was caught at that time with spears as well as by means of hook and line. In the "Yengishiki", a classical work compiled between 900—927, we find names of several kinds of food, prepared from the mackerel and the striped bonito. These products were paid as tribute to the Imperial court and the Government from several provinces round our coasts. In that classical work, names of tunnies and seerfishes are not mentioned, though tunnies at least were caught before that time. From the name of "sawara" for our common seerfish, we can guess that they have long been known to us, as that name in our old language means narrow abdomen, and it is just as old as the name "saba" for the mackerel, meaning narrow or minute teeth. From the twelfth century on, on account of many wars, most industries were disturbed and retrograded, until peace was restored by the consolidation of a central government in the seventeenth century, under the control of HIDEYOSHI TOYOTOMI. From an anecdote, however, we learn that an ingenius pound-net was planned and constructed in the period of wars in a bay near Sendai by a soldier, who got his idea from tactics in war. The device is a trap, with an elongated pound, the longer diameter of which is at right angles to the course of the leader. The pound as well as the leader have a certain curvature, which prevents the escape of fish at the mouth of the pound, and when the mouth is closed, at the bent corners of leaders, which are set in different directions. The apparatus first designed for the capture of the tunny has recently been employed in many other places for the capture of seerfishes, yellow-tails, etc. and it has proved to be superior to other types, having the longer diameter of the pound in the same direction as the leader. I is really remarkable that a fishing implement invented in the northeastern part of our empire was introduced to other places. Generally the reverse is true, i. e. implements or methods invented in the central or western parts have travelled to the northeast.

Nearly all kinds of fishing apparatus are used for the capture of scombroid fishes, except casting nets and dredges. As many kinds of these fishes form large schools, the apparatus for their capture is generally large; but its height is mostly under 60 m.

As most scombroid fishes are swift swimmers, fishermen try to retard their progress by scattering tole baits. These fishes are enticed to the artificial baits in motion. The mackerel is attracted to light at night, *Acanthocybium* to the shade of moored bundles of bamboo-stems or branches of *Paulownia imperialis*. Fishing with drift-nets is popular, but not good in clear waters, where other kinds of nets are also not suitable. In such grounds hook and line are the best means for catching.

Though the scombroid fishes are very widely distributed, their food is very plentiful, and their immature specimens are not molested by men, yet they become gradually scarce in old fishing grounds. Generally the scombroid fishes do not stay many days in the same place. It seems wise to change the fishing ground from time to time, not adhering to the same locality. Many unfortunate accidents occur in this hazardous occupation, as the fishing grounds are rough, lying generally very far from the coast. Moreover the fishing apparatus is large, and the cost of the individual fish high, so fishermen try to haul in the whole apparatus even in case of sudden storms, and thus often fail to return to safety in good time. For the future development of the fishery of the scombroid fishes, it is desirable to build swift, sea-going boats, to discover good means of attracting these fishes, and to provide a suitable equipment for preserving these fishes, as they are much more perishable than other kinds. Fishermen detect the presence of these fishes by their leaping out of the water, by the movements of birds, the colour of the water, or peculiar waves or movements of the water at the surface of the sea. They use the troll line to detect the presence of these fishes in deep strata of water.

Hook and Line.

In the mackerel fishery there are five kinds of hook and line fishery—rod and line, casting line, ordinary hand-line, troll line, and long line—of which the third and fifth are widely used. The ordinary hand-line is nearly so long as the depth of the fishing ground. The gear consists of a spreader or a lever, to which a sinker and a bag for tole bait are attached. The long line is also largely used. It is a drift line, suspended from barrels by means of buoy-lines, weighed sometimes with light weights. Hooks of these lines are dressed with small pieces of sardine, saurel, or mackerel itself. The artificial bait is seldom used. Gangings of the hand-line are of worm-gut. The hand-line gear is essentially like that for the saurel.

In the seerfish fishery three kinds of hook and line are used;—hand-line, troll line, and long line. The troll line is most popular and efficient. As seerfishes are voracious, it is difficult to catch them with baits of little motion. And as they do not come to the surface it is impossible to catch them with rods. Good fishing grounds lie near straits or rocky banks. The troll line for the common seerfish is like that for *Seriola quinqueradiata*. The length of the gear is from about 40 to 200 m or more. Generally it is 60–100 m. The line is tarred and on it numerous small lead sinkers are distributed. When the line is short the weight is heavy, but if it is long, the weight is comparatively light. The hook has a long shank and is angular in form. As seerfishes have trenchant teeth, about 20 cm of the snood is made of a metallic wire.

In the tunny fishery, rod and line, hand-line, troll line, and long line are used. The long line is the most important. As tunnies are big and swift in locomotion, the gear must be thick, stout, and long. When tunnies bite the hook, they swim away at once furiously and irresistibly, until they are tired, so that the gear must be sufficiently long to allow it. Lines are generally made of hemp, and the lower end of the snoods at least is served with fine thread or wire. To the gears for the tunny, sinkers are seldom added. The minimum length of gear for the tunny is 200 m. The tunny long line is very thick, strong and 400–500 m long, coiled in a basket. Each boat shoots out lines of 10–15 baskets. The line is also a drift line, suspended at the intermediate depth by means of buoy-lines of 10–25 m. As the ground-line itself is thick and heavy, there is no need of sinkers. There are two kinds of gangings,—short and long. The former is ca 12 m, and the latter ca 37 m. A line from each basket is divided into three sections by five buoy-lines, two of which are attached to both ends. Each section is again subdivided into four by three gangings, the middle of which is the longer one. This long line is generally worked at night. The long line fishery of tunnies seems to have first been tried near the mouth of Tokyo Bay, about three centuries ago, and it was introduced in recent years to other parts of our country. Formerly a peculiar kind of fishing line for tunnies was used in the central and western parts. The line is about 200 m in length, and is wound round a small barrel, leaving about one quarter of the line to hang free. At the end of the free portion a hook dressed with a live bait is attached. A boat, with a crew of about half a dozen men, carries ten or more lines, which they leave in the sea to drift. When a tunny bites the hook, the barrel sinks at once, but as the wound part of the line becomes loose, the barrel arises whirling.

In the bonito fishery rod and line, troll line, and long line are used, but the first is most extensively used. As bonitos swim near the surface and do not descend to deeper strata of water, the fishing with rod and line is simple and convenient, no sinkers are used. It is remarkable that fishing of bonito with rod and line is done in our country and at Minikoy, a small island in the Indian Ocean, in nearly the same way. For the rod a bamboo-stem of about seven metres is used. Around the thicker end of the stem a string is roughly wound to prevent the hand from slipping. The line is nearly the same in length as the rod, and about 30 cm of the terminal portion is dyed with indigo. The hook lacks the barb, and is dressed with living sardine or anchovy. Fishermen hold their rods in such a way as to a low the living bait to swim at the surface of the sea. With artificial bait short rods of about three and half metres and a line of 120 cm long and of thick diameter are used. While fishing, living fish are thrown as tole bait far and near.

Drift Nets.

Drift nets for different scombroid fishes differ in the size of meshes, depth, length, and the thickness of the twine. For small fishes drift nets are gill-nets, but for tunnies there is no gill-net. Drift nets for scombroid fishes are generally worked in warm seasons. Drift nets for tunnies and bonitos are shot at the surface of the sea; but those for the mackerel and seerfishes are suspended in more or less lower strata of water, by means of buoy-lines of some length. These nets are worked at night. Sometimes gill-nets are shot with both ends bent towards the school of fish and they are driven towards the net. When the tunny strikes the net, it yields to the movement of the fish, and forming a pocket passes over the float line and is hung back. Thus when the height of the tunny drift net is too high, the capture is not satisfactory. The tunny drift net is chiefly used on the Pacific coast of the northeastern part of Hondo.

SEINES.

Seines for scombroid fishes are also chiefly used in the warm season. The size of the meshes is proportional to that of the fish to be caught; but it is very small in the seine for our common seerfish, or its bunt is made of coarse cloth, woven with strong thread. This is to prevent the penetration of the jaws of the fish into the netting, lest the seine should be damaged by their trenchant teeth. Seines for scombroid fishes are mostly 70–85 m deep, and 500–1000 or more long. In some of these seines the wings are made of straw nettings. Seines for the common seerfish are used in the Inland Sea only, and are hauled towards the land, while those for the other scombroid fishes are hauled into boats. Tunnies captured with seines are *Thunnus orientalis* and *Neothunnus macropterus.* The striped bonito is sometimes captured with seines. Before the development of seines for tunnies and bonitos schools of fishes were surrounded with a long wall of net, and then the fish were scooped out with a kind of large dip-net.

POUND-NETS.

Special pound-nets are built for the capture of *Thunnus orientalis* and *Neothunnus macropterus* in warm seasons, when these fishes migrate northward. In some places pound-nets for the capture of tunnies in their southern migration are erected; but these are very few in number, and are not so important as the other. The pound-nets for *Thunnus orientalis* in their northern migration are very important, and very abundant. Other scombroid fishes are also caught in large numbers in pound-nets; but their time of appearance is rather short, or occasional, and the expenses of pound-net fishery can not be sustained by these fishes only.

There are different types of pound-nets for the capture of tunnies developed at different parts of our empire. But as I have stated before, a type called "daiboami", developed near Sendai is at present the most advanced one. It resembles in form the madrague of the Mediterranean, but in our pound-net the bottom is entirely closed with netting, and there are no dividing walls. The movement of the fish is observed by the boat crew by signals from a watch-tower, on a wooden frame-work, erected from the sea-bottom, or on a precipice near by. At the strait of Tsugaru the watchman observes the fish by transmitted light from the sea, seated under a cover of matting, which partly hangs over the sea, from the side of his boat. In the case of the daiboami, the watchman takes his post just opposite the entrance of the pound. In other more simple cases the watchman is seated in the boat at the mouth. When a school of fish enters the pound, its entrance is closed by lifting up the sunken netting, connected with the bottom of the net, and the bottom is hauled over from one end to the other, the bunt. The depth of water at the entrance of the pound should be more than 15 m. Effective pound-nets for the tunny are about 30 m deep at their entrance. The size of the pound-net generally in use is 430 m in circumference, and ca 150 m in the longer diameter. The mackerel and the common seerfish are caught in pound nets for *Seriola quinqueradiata* or miscellaneous fishes.

Classification.

So far as I have studied, the natural affinities of fishes can not be ascertained from the examination of external characters only. Some authors classify the genus *Auxis* near *Scomber*, as the two dorsals are separated, but in reality these two genera are at both extremities of the phylum of the scombroid fishes.

Order TELEOSTEI.

Suborder **Acanthopterygii.**

Family SCOMBRIDAE (s. str.) Günther.

Scombridae (in part), Günther, 1860.
Scombrinae, Jordan & Evermann, 1896; Starks, 1910.
Scombridae (in part), Boulenger, 1904; Regan, 1909.
Scombridae, Kishinouye, 1915.

Body fusiform, and more or less compressed. Head pointed at the anterior end, its upper surface flattened and naked, but the opercles are scaly. Caudal peduncle rounded in cross-section, having no lateral keel. A pair of small keels are found on each side of the tail. Lateral line gently curved, wanting marked bendings or undulations. Adipose eyelids present. Scales cycloid, often finely crenulated or more or less ctenoid at the posterior margin. Corselet indistinct. The scales at the pectoral region have the same structure as those in the remaining regions, but the former are only a little larger than the latter. The former are not covered with a connective tissue membrane. Postorbital scales rather large, unequal in size. In the ventral half of the body, rows of scales run nearly parallel to the ventral median line of the caudal region.

Mouth large with minute teeth. Tongue very small and smooth. The maxillary is almost entirely covered by the preorbital, and the supplementary bone at the posterior end is very small, slender and insignificant. Premaxillaries are very slender and weak. Gill-rakers very numerous, long, slender and much compressed, with two rows of fine diverging pairs of long denticles on the inner side. Gill-lamellae very short at the angle of gill-arches. Branchiostegal membranes very broad and overlapping each other at the symphysis.

Opercle short, and notched at the posterior margin. Subopercle very narrow. Preopercle comparatively large, rounded and expanded at the lower posterior corner. Clavicular ligament is inserted at the posterior end of the exoccipital. Fins not well developed. Interspinous bones are weak and slender. Fin-rays are transversely articulated. The second dorsal is lower than the first and the two dorsals are distinctly separated from each other. The first spine of the first dorsal is shorter than some succeeding spines. The second dorsal and the anal are covered with small elongated scales.

The abdominal cavity is ellipsoid in cross-section, with the longer diameter vertical. Peritoneum generally black. Pylorus ascending. Pyloric coeca numerous, arranged in many longitudinal rows. They are rather large, opening directly to the duodenum, and are loosely connected with connective tissue fibres. Alimentary canal long and folded. The liver is a small triangular mass, occupying the left anterior corner of the abdominal cavity. Kidneys thin, elongated and divided into two before the pharyngeal muscle, which is inserted into the third or fourth vertebra, or into both.

Skeleton thin, but firm. Skull elongated and the greater part of the frontals lies directly under the skin. Occipital crest low and small. Sphenotic and opisthotic not visible at the dorsal surface of the skull. The exclusion of the opisthotic from the dorsal surface of the skull is quite the same as in the Carangidae. Accessory lateral ridges are found on the dorsal surface of the skull. Occipital condyle is remarkably hollow. Paroccipital condyles are oblique, turned externally, and are separated from each other by the foramen magnum. Articulating facets of the skull with the atlas are on both sides of the foramen magnum and do not form a part of the margin of the foramen. Vertebrae generally 31 in number, they differ but little from each other in form, size, different processes, etc. No transverse process. Lateral ridges in the anterior vertebrae pass gradually to the ventral ridges in the vertebrae of the posterior region.

First vertebra, the atlas, is remarkable in having a pair of large, articulating processes projecting, instead of declining obliquely backward, and also in having the neural process attached to the centrum (fig. 30). In precaudal vertebrae the neural canal is entirely covered with an arching septum to protect the spinal cord, and is separated from the ligament of the vertebral column, occupying the dorsal part of the neural canal. The neural process of the precaudal vertebrae is more flexible and more feeble than that of the caudal vertebrae. In the caudal vertebrae prezygapophyses and the anterior ventral processes are especially well developed. The last vertebra and the hypural bones are not consolidated together. No auxiliary intermuscular bones are found in the cephalic region. Ribs are not much compressed and hang down the abdominal wall. Pelvic girdle very small. Antero-inferior corner of the dorsal flattened part of the hyomandibular is free and rounded (fig. B). The free trenchant edge of the palatine is armed with a row of teeth in the genus *Scomber*. In the lower piece of the post-clavicle we distinguish the broad proximal part with a short slender anterior process, and a long slender distal part. Ethmoid is narrow and produced anteriorly beyond the paired lateral processes. The basibranchial chain is narrow, laterally compressed, elongated, and nearly straight.

This family is more or less related to the Carangidae, in the presence of the adipose eye-lids, free spines before the anal fin, transversely articulated fin-rays, and opercle with a dorsal notch, narrow subopercle, etc. But the family is distinguished from the Carangidae in wanting characters of the Perciform fishes—narrow premaxillary which is not protractile and wants a dorsal process, and a small supplementary bone attached to the posterior end of the premaxillary. This family has remote relations to the Cybiidae. The genus *Grammatorcynus* of the Cybiidae has the same number of vertebrae as the mackerels, and pyloric coeca are also more or less alike.

STARKS (69) rightly remarks that "if we could eliminate the genus *Scomber*, the family (Scombridae in wide sense) would be much more compact, as it stands farther from the other genera than they do from each other."

Mackerels are rather small, grow to a length of about 40 cm. and a weight of about one kg. They swim generally in the middle or lower layers of the coastal water, and enter into bays and inlets, in shoals. Widely distributed in temperate and subtropical regions.

Key to the genera of the Scombridae.

Body elongated and fusiform, vomer and palatines toothed. ....*Scomber*.
Body deep and compressed, vomer and palatines toothless, gill-rakers very long, visible from the gape of the mouth, interspinous bones of the second dorsal and the anal are flattened. ....*Rastrelliger*.

Genus **Scomber**.

Scomber, Linnaeus (s. str.) 1758; Cuvier, 1817.

Teeth minute, in both jaws in one row, on the vomer in paired oblique patches and on palatines in one row.

Only two good species are known, and only one species is found in the Pacific Ocean.

Scomber japonicus Houttouyn.

Saba.

Figs. 1, 7, 16, 28–30.

Scomber japonicus Houttouyn, Memoires de Harlem, XX, 331, 1782; Lacépède, Hist. Nat. Poiss. III, 45, 1802; Cuv. & Val. Hist. Nat. Poiss. VIII, 54, 1831; Kishinouye, Sui. Gak. Ho, I, 4, Pl. I, Fig. 1, 1915.
Scomber pneumatophorus Schlegel, Fauna Japon., Poiss. 91, Tab. 47, Figs. 1, 2, 1850.
Scomber saba Bleeker, Verh. Bat. Gen. XXVI, 95, 1857.
Scomber janesaba Bleeker, Verh. Bat. Gen. XXVI, 96, 1857.
? *Scomber tapeinocephalus* Bleeker, Verh. Bat. Gen. XXVI, 97, Tab. 7, Fig. 2, 1857.
Scomber colias Kishinouye, Journ. Fish. Bureau, II, 1, Pls. I, II, 1893.

D. 9–12, 12, 5. A. 1, 12–13, 5. Vert. 14+17. Gill-rakers 13+23.

Body fusiform and compressed, its height nearly equal to the length of the head. Teeth minute, about 60 in each jaw. The scales in the dorsal half of the body are arranged in nearly horizontal rows, while those in the ventral half are arranged in oblique rows, more or less parallel to the ventral median line of the caudal region, i. e. ventral outline.

Air-bladder large and fusiform, pointed at both ends. Pyloric coeca near the pylorus are longer and more numerous than those removed from it. The pyloric portion as well as the duodenum are ascending, the latter runs from left to right, occupying the most anterior border of the abdominal cavity. At the right corner of the cavity the duodenum passes to the small intestine, which runs backward, then bent forward, a little before the anus, and it is bent again backward. A little behind the second bend the small intestine ends and is followed by the rectum.

About three small veins from the pyloric coeca form the portal veins; two veins running upon the dorsal surface of the stomach do not form the hepatic portal veins, but pour directly to the ductus Cuvieri.

A free spine before the anal is about one fourth the length of the first anal spine. Each dorsal or anal finlet is sometimes connected with the body by a membrane behind it.

Dark branching zigzag bands, about thirty in number, are found in the back. The number of these bands is nearly the same as that of the vertebrae and their course generally corresponds or coincides with the contour line between myotomes. Back bluish green, the colour becoming lighter towards the tail. Belly silvery white with irridescent lights. Fins greyish more or less washed with yellow. The space between the posterior nostril and the eye is nearly colourless and transparent. The dorsal fins and dorsal finlets, pectorals, and the caudal are greyish, and sometimes washed with yellow. The ventrals, anal, and anal finlets are colourless.

Among our common mackerel we find two different types which fishermen distinguish under the names of "hirasaba" and "marusaba", meaning respectively flat and round. In the internal structure we can hardly distinguish them; but in some external characters and habitat they differ more or less. A comparison of fig. 28 with fig. 29 will give the reader a very good idea of these differences. However, as there are many intermediate forms between these two types of forms, I can not take them as different species. In the typical hirasaba we count 9 spines in the first dorsal, while there are 11–12 in the typical marusaba. Moreover in the former variety the dark coloured bands in the back run down beyond the lateral median line. In that variety the caudal fin is yellowish. The fish lives near the coast, but in deeper layers of water. Its flesh is more oily and palatable. In the other variety which is also called "gomasaba" the dark coloured bands in the back are found, only above the lateral median line. On that line there is a row of round spots, and below the line there are numerous greyish spots. It is chiefly found in off-shore grounds and in shallower strata of water, making larger shoals than the former variety.

This species inhabits rather littoral waters, and its range of distribution in our country is very wide, from Karafuto to Taiwan. On our coast this species is rarely found in layers of water deeper than about a hundred metres. We observe more or less the bathybial as well as latitudinal migration of the mackerel. In spring the mackerel enters the Inland Sea, and in summer it is caught off Notasan, west coast of Karafuto. In winter it is caught near Tanegashima, Kagoshima-ken. In Hondo it is caught all the year round, but large catches are expected in summer and autumn. It is also caught abundantly on the east coast of Chosen, especially near the Channel of Chosen. At the Channel of Chosen, i. e. at the southern entrance of the Japan Sea, mackerels make thick shoals in spring and autumn. Two hundred and sixty thousand mackerel with a part of saurel were caught in a haul with a purse seine. Sometimes two millions of mackerel are landed in the port of Hōgyoshin near Fusan in one day. Mackerel are caught in twilight when they come to shallower layers of water. In cloudy weather they often rise to the surface.

Adult mackerel approach the twenty metre line shoreward, and are distributed a little beyond the two hundred metre line. They are never found in the Kuroshiwo, being found in waters of 10–20° C. On a cold day and during the cold season mackerel are found near the bottom of the sea. The optimum density for the mackerel is 1.025.

Mackerel spawn in May. Fry and the immature fish are found among those of the sardine, anchovy, and the saurel. They grow very rapidly, feeding on fries of other fishes. When they are about 36 cm in length and $\frac{1}{2}$ kg in weight, they are ripe for the first time. The age of these fishes is not exactly known. They may be two or three years old. Fish of about 60 cm long and $1\frac{1}{2}$ kg in weight are very large and rare.

In olden times fishermen attracted fish with torch-light, but at present electric lamps, acetylene light, etc. are used. The light attracts many planctonic animals near the surface of the sea, and they in turn attract the mackerel, and other animals such as saurel, calamaries, etc., gradually towards the surface of the sea. Thus the time used in catching the mackerel is greatly economised. Besides light, tole bait is much used to attract the fish. Salted mantis-shrimp is chiefly used for the purpose. Long lines and drift nets are extensively used in the Japan Sea. Encircling seines, such as the purse seine and "shibari-ami" are chiefly used in the southern part of Chosen.

The mackerel fishery is carried on on a rather small scale, with hand lines, long lines, or drift nets. The hand-line is most extensively used. The gear consists of a line of about 100 m, two brass outriggers or spreaders, each ca 30 cm long, spreading from both sides of a conical lead, three to four hundeed gr in weight. A worm-gut snood 2 m long is generally fastened to each outrigger, with a small hook at the distal end. A small bag is usually fastened to the lead to hold tole bait. Immature mackerel or yearlings are caught in large quantities with haul-seines in shallow waters.

Genus **Rastrelliger** Jordan & Starks.

Rastrelliger, Jordan & Dickerson, 1908.

Body deeply compressed. Mouth large, maxillary nearly reaching the posterior edge of the eye. Dentition feeble, the vomer and palatines toothless. Gillrakers exceedingly long and numerous. Intestine very long, bent several times. Found in tropical and subtropical regions of the Indo-Pacific.

Rastrelliger chrysozonus (Rüppel).

Gurukun (Ryukyu Is.), murehji (Naha, Ryukyu).

Fig 63.

Scomber chrysozonus Rüppel, N. W. Fische, 37, Taf. XI, Fig. 1, 1838,
Scomber microlepidotus, Day, Fish. India, 250, Pl. LIV, Figs. 3—6, 1875—78; Kitahara, Journ. Fish. Bureau, VI, 5, Pl. III, Fig. 5, 1897.
Scomber kanagurta, Jordan and Richardson, Mem. Carnegie Mus., 1909.
Rastrelliger chrysozonus, Kishinouye, Sui, Gaku. Ho, I, 8, 1915.

D. 10, 12, 5. A. 12, 5. Vert. 13+18.

In freshly preserved specimens in formalin the back is bluish with greenish lustre in the anterior part, a row of greyish dots on each side of the base of the dorsals, two greenish grey longitudinal bands above the lateral line, and two golden longitudinal bands from the base of the pectoral. Cheeks and belly silvery. Two dorsals and dorsal finlets greyish, and the anal and anal finlets colourless or tinged with yellow. Peritonium black. Interspinous bones of the second dorsal and anal are flattened, and laterally compressed.

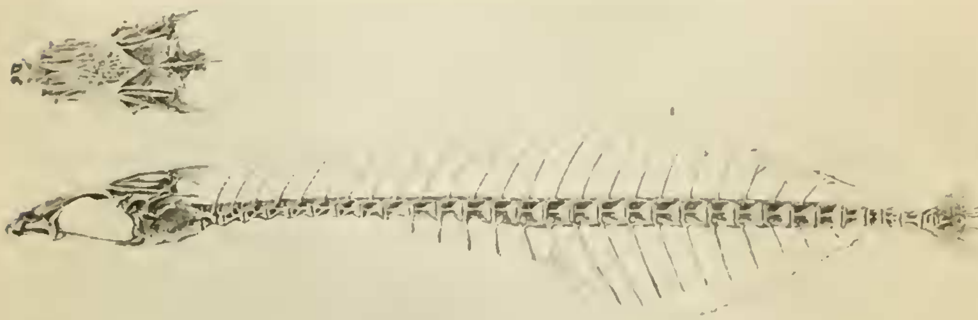


Fig. W. Skeleton of *Rastrelliger chrysozonus.* 3/5.

Membrane connecting the branchiostegals is very wide. The last branchiostegal is bent like the letter L. Pyloric coeca are more or less united to numerous groups at their root, and each group to the duodenum with a common orifice. In the caudal vertebrae thin paired ridges are found on the ventral side.

It is said that shoals of this fish are observed on a calm day seething near the surface of shallow water, busily feeding on minute planktonic organisms. The fish are very alert and not easy to catch. In the Ryukyu Islands small individuals are caught in summer, and large ones in winter.

DAY found that the ova ripen in March. It grows to a length of ca 35 cm.

Widely distributed in tropical and subtropical regions of the Indo-Pacific. Specimens from southern China, Formosa and Truck Is. were examined.

Family CYBIIDAE Kishinouye.

Cybiidae, Kishinouye, Sui. Gak. Ho, I, 6, 1915.

Body generally elongated and compressed, but plump in the genera *Sarda* and *Gymnosarda.* Caudal peduncle pretty thick and nearly rounded in cross-section, and provided with a large keel on each side. The keel is covered with elongated scales, except in *Sarda*. Head elongated with a long snout. Mouth large, and wide, the maxillary extending beyond the hinder margin of the eye. Eyes generally small. Posterior margin of the upper jaw, or that of the jugal in the strict sense, is more or less rounded, as the supplementary bone is well developed. Teeth in jaws are in one row only. They are large, curved inward, and compressed with trenchant edges. Tongue large, rounded, convex, but the glossohyal is comparatively small and narrow.

Corselet small, more or less distinct, but its scales are not much specialised. Scales small, generally cycloid, and often concealed under the skin. Sometimes scales disappear entirely outside of the corselet, lateral line, and caudal peduncle. Lateral line sinuous, particularly in the posterior portion of the body, and the line is often furnished with many minute branches (figs. 31, 32, 35, 61).

Fins generally small, especially ventrals, but the caudal fin is comparatively large. Fin-rays are not transversely articulated in the adult fish. Pectorals are comparatively small. First dorsal low and long, gradually descending posteriorly, and its spines are rather weak. First dorsal has generally a straight or more or less convex outline, except in *Acanthocybium*. The first spine of the first dorsal is shorter and weaker than some following spines. There is scarcely an interspace between the first and second dorsal, and the latter is generally a little higher than the first dorsal, except in *Grammatorcynus* and *Acanthocybium*.

Peritoneum more or less dusky. Stomach long and narrow, with 12–30 longitudinal folds inside. Pylorus opens very near the cardiac portion; it is long, narrow, descending, and communicates with a narrow opening at the ventral side near the distal end. Duodenum curved or twisted, enlarged with two or more branching pyloric tubes high at the posterior side, disposed more or less in a whorl round the intestine. Pyloric coeca at the end of the terminal branch of these tubes branch dendritically. Intestine is often very long and bent several times.

Skeleton is generally spongy, light, and more or less fragile. It is more or less solid in *Acanthocybium* and quite firm in *Gymnosarda*. Skull elongated, with low and weak occipital crests. Vomer is generally flat, more or less produced, and covered with villiform teeth, except in *Sarda* and *Gymnosarda*. Anterior lateral corner of the ethmoid is more or less produced.

Foramen between the basioccipital and parasphenoid is small and opens nearly in a horizontal plane. Paroccipital condyles touch each other at the median line, and the occipital condyle is only slightly concave. Number of vertebrae is 31–64, generally more than forty, and varies greatly even among closely allied species. Relative number of the caudal and precaudal vertebrae is also variable. Differentiation of vertebrae is a little more advanced than in the Scombridae. Sometimes I found abnormal cases in which two or more vertebrae fused together. Longitudinal grooves in vertebrae are deep, and thus the cross-section of most vertebrae show a six-radiating figure (figs. 8–12). In some posterior precaudal vertebrae a short haemal process is formd. Neural process is broad in some anterior precaudal vertebrae, and the process of the first vertebra is free from the centrum. The last caudal vertebra is consolidated with the hypural bones, and forms a fan-shaped bone with a notch at the median posterior corner. Hypural spine very prominent, but rather small in *Sarda* and *Gymnosarda*. One or two auxiliary intermuscular bones are found in the occipital region, where the clavicular ligament is inserted. Intermuscular bones are weakly developed at the anterior portion of the body only, connected by a few and poor tendons.

Gill-rakers are very poorly developed in the Cybiidae. They are short, not much compressed, generally a little more than ten in number, and entirely absent in *Acanthocybium*. A few gill-rakers are found near the angle of the second branchial arch in some forms. Two or more rows of short denticles are found on the inner side of gill-rakers. Ribs are found on the dorsal wall of the body-cavity, as myotomes are bent with acute angles. Pelvic girdle narrow and elongated. Generally the lower piece of the postclavicle is nearly straight.

The vascular system of the Cybiidae has many characteristics:—development of the renal portal system from dorsal segmental veins in the precaudal region, origination of the genital artery from the dorsal aorta, remarkable separation of the dorsal aorta from the cardinal vein with the intervention of rete mirabilis of the renal portal system between them. Ureters of both sides are entirely separated. Kidneys elongated. Muscles nearly colourless, but the median superficial lateral portion is reddish. This reddish portion becomes rather thick posteriorly (fig. 17).

The posterior side of the preopercle is generally a little concave in *Cybium* and *Grammatorcynus.* The second basibranchial is bent downward at the middle.

Neural and haemal spines of the caudal vertebrae are not straight, but more or less curved. The haemal arch in the precaudal vertebrae is short, and turned anteriorly, the haemal spine is little developed in the precaudal region.

Seerfishes are generally active when the sea is rough, and the current strong, also in the morning and in cloudy weather. They often leap out of the water, and when they are impounded in a net, they try to get out of it through the meshes at the bottom, especially at night. Generally they swim near the shore, but some of them are chiefly pelagic. Many of them assemble and form big shoals, and approach the shore in the breeding season. They are predaceous fish, they feed on small fish such as sardines, anchovies, saurels, mackerel, and sometimes shrimps and calamaries. Found in the temperate and tropical seas. Many of them are excellent food-fish. Small immature specimens of the Cybiidae are more or less flat and broad, larger specimens are thick and elongated, quite contrary to the case of the Katsuwonidae.

This family is related on one hand to the Xiphiidae in the reticulate gills, absence of gill-rakers, small narrow scales, etc. through the genus *Acanthocybium*, to the Scombridae through the genus *Grammatorcynus*, and to the Plecostei in the form of the body, osteological structures etc. through the genera *Sarda* and *Gymnosarda*. This family comprises the Scombrinae, Acanthocybinae, and Sardinae of STARKS.

Key to the Japanese genera of the Cybiidae.

Body elongated, teeth in jaws trenchant, vomerine teeth present.
- Gill-rakers none, gill-lamellae reticulated, intermuscular bones inserted on ribs .... *Acanthocybium.*
- Gill-rakers present, gill-lamellae not reticulated, intermuscular bones inserted on respective vertebrae.
  - Two lateral lines on each side of the body .... *Grammatorcynus.*
  - Only one lateral line on each side of the body........................ *Cybium.*

Body plump, teeth in jaws with rounded edges, vomerine teeth absent.
- Body covered entirely with small scales, tongue toothless .... *Sarda.*
- Body naked outside of the corselet, tongue covered with villous teeth, palatines are also toothed .... *Gymnosarda.*

Genus **Acanthocybium** Gill.

Acanthocybium, Gill, 1862; Lütken, 1880; Jordan & Evermann, 1896.

This genus comprises a rather aberrant form, more or less related to the Xiphiidae. Body elongated, more or less compressed, and covered with small narrow scales. Premaxillary produced anteriorly. Preorbital forms the posterior half of the upper jaw. Teeth triangular, compressed, and closely set. Branchial lamellae are reticulated at the proximal part. Gill-rakers absent. Intermuscular bones are inserted on ribs. The first rib is found on the second vertebra, not on the third as in the other. Moreover the rib is shorter than the intermuscular bone inserted on it. No auxiliary intermuscular bone, and the first intermuscular bone is inserted on the first vertebra. Pelvic girdle broad.

Pelagic and predaceous fish of about two metres. Tropical and subtropical seas of the Pacific and Atlantic.

Acanthocybium solandri (Cuv. & Val.)

Kamasusawara, ōkamasu, okisawara, sawara (Kochi-ken, Kyushyu, Ogasawara Is.), tessahku (Taiwan), tōjinsawara.

Figs. 10, 31, 39.

Cybium solandri, Cuv. & Val., Hist. Nat. Poiss. VIII, 192, 1831.
? *Cybium sara*, Bennett, Beechy's Voyage, Fish, 63, Pl. 20, Fig. 2, 1839.
Acanthocybium solandri, Jenkins, Bull. U. S. Fish Com., XXII, 111, 1904; Kishinouye, Dobutsu. Zas. XX, 2, Pl. 2, Fig. 2, 1908.
? *Acanthocybium forbesi*, Seale, Philip. Journ. Sci. Biol. VII, 283, 1912.
Acanthocybium sara, Kishinouye, Sui. Gak. Ho, I, 9, Pl. I, Fig. 2, 1915.

B. 7. D. 26, 11, 9. A. 11, 9. Vert. 23-33+31. Gill-rakers O.

Body elongated and compressed, covered with thin small lanceolate scales. Corselet indistinct. First dorsal well developed, descending near the posterior end, but its greater part has nearly the same breadth. Second dorsal and the anal very small. Caudal fin lunate and powerful. Lateral line is suddenly and strongly curved, under the middle of the first dorsal. Many vertical branches are given off from both sides of the lateral line. Those branches found in the posterior half of the body are longer and more numerous. In each jaw about 50-55 triangular teeth, which gradually increase in size posteriorly. Vomer and palatines with villous teeth. First rib on the second vertebra (STARKS (69) found the first rib on the third).

Stomach conical and very long, reaching a little behind the anterior end of the rectum. Pylorus short, curved, and descending, duodenum more or less widened, with three or four pyloric tubes, the shortest of them is at the anterior side, and the longest is furthest removed from the pylorus. Intestine is narrow and straight. Air-bladder long, more or less spindle-shaped, running the whole length of the abdominal cavity. Urinary bladder is very long and is found attached to the ventral wall of the air-bladder, and above the rectum in the abdominal cavity. Two ureters unite to a median canal near the end of the blended kidneys, and open to the posterior end of the bladder.

This species is found chiefly in the clear warm water of the tropical and subtropical seas, and is found at the mouth of Tokyo Bay in the east, from Shimane-ken, Kyoto-fu, and at the north of the southern coast of Chosen. A few examples are nearly always found in the markets of southern Kyushyu in summer and autumn. In the Ogasawara Islands this fish is cut into pieces and dried after boiling, or is preserved in hermetic cans.

Pelagic fish, do not make a school. They feed on pelagic fish and calamaries. Voracious and easily attracted with natural or artificial baits. Caught with trolling lines, which are dressed with live or salted saurel, or with spears after alluring with artificial fish, made of wood or canvas to imitate flying fish or its own species. In Kochi-ken and Kagoshima-ken the fish is attracted to the shade of a large bundle of bamboo stems or branches of some light wood, moored in off-shore grounds, specially constructed for the purpose.

The colour of the fish is steel-blue in the back, with about thirty dark transverse bands, which are distinct in young fishes, and in the adult fish when excited. Dorsals, pectorals, and caudal are blackish, while the ventrals are dusky.

A fish about one and half metres in length, and about seventeen kg in weight, caught off Hachijoshima in June contained nearly ripe ovaries. Another fish of similar size, caught off the Ogasawara Islands in August, 1919 contained much more slender ovaries than the preceding. An immature fish, 28 cm in the total lenghth was caught by a bonito-angler off Daiozaki, Miyeken on Aug. 19, 1917.

When speared the fish darts against the bottom, and then floats to the surface dead.

A large species of distomum, about 8 cm in length, is almost always found in the stomach.

Genus **Grammatorcynus** Gill.

Grammatorcynus, Gill, 1862; Klunzinger, 1884.
Nesogrammus, Evermann & Seale, 1807.

Body elongated, compressed, and covered with small scales. Corselet indistinct. Mouth rather small, maxillary not reaching the middle of the eye. A deep groove in the skin from the corner of the mouth, as in many other forms of the mackerel-like fishes. Tongue broad. Teeth elongated, trenchant. Villous teeth on the vomer and palatines. Two dorsals continuous. Second dorsal and anal are divided into finlets in the hind part, and are lower than the first dorsal. Gill-rakers short and strong. Opercle with a shallow notch at the posterior margin. The lateral keel of the caudal peduncle is low and small, covered with a row of pored scales. Two lateral lines on each side of the body.

Fish of this genus are also an aberrant form of the Cybiidae. The insignificant keel on the caudal peduncle, the rather small number of vertebrae, indistinct corselet, slightly notched opercle, backward origin of the first dorsal etc. connect this genus more or less with the Scombridae; but trenchant teeth, continuous dorsals, large broad tongue, renal portal veins, short strong gill-rakers, descending pylorus, dendritic tubes to which pyloric coeca open, bent second basibranchial, etc. indicate that this genus is much closer to the other genera of the Cybiidae.

Only one species is known from the tropical seas and adjacent waters of the Indo-Pacific region.

Grammatorcynus bilineatus (Rüppel).

Kusarah.

Figs 8, 62.

Thynnus bilineatus, Rüppel, N. W. Fische. 39, Taf. 12, Fig. 2, 1849; Günther, Cat. II, 366, 1860.
Grammatorcynus bilineatus, Gill, Proc. Ac. Philad. 125 1862. Klunzinger, Fisch. Roth Meer, 113, 1884; Kishinouye, Sui. Gak. Ho, I, 86. 1915
Nesogrammus piersoni, Evermann & Seale, Bull. Bur. Fish. XXVI, 61, 1907.

D. 12, 9, 7. A. 10, 7. Gill-rakers 5+16. Vert. 13+18.

Body elongated, fusiform, covered with small thin scales. The cheeks are covered with many small scales. Top of the head flat, and the greater part of the frontals is directly covered by the skin. Eyes large. Vomer flattened, villous teeth in a median group. Occipital crest low. Opisthotic forms a small portion at the posterior dorsal portion of the skull. No auxiliary intermuscular bone. The first dorsal interspinous bone seems to belong to the myotome of the second vertebra, as in the case of the Scombridae. The second dorsal and anal are covered entirely with elongated narrow scales. The ventral or the external side of pectorals is also covered with similar scales. Teeth in jaws are small with trenchant edges, about 27 in the upper, and about 20 in the lower. The condylar facet of the basioccipital is slightly hollow and oblique. Arti-

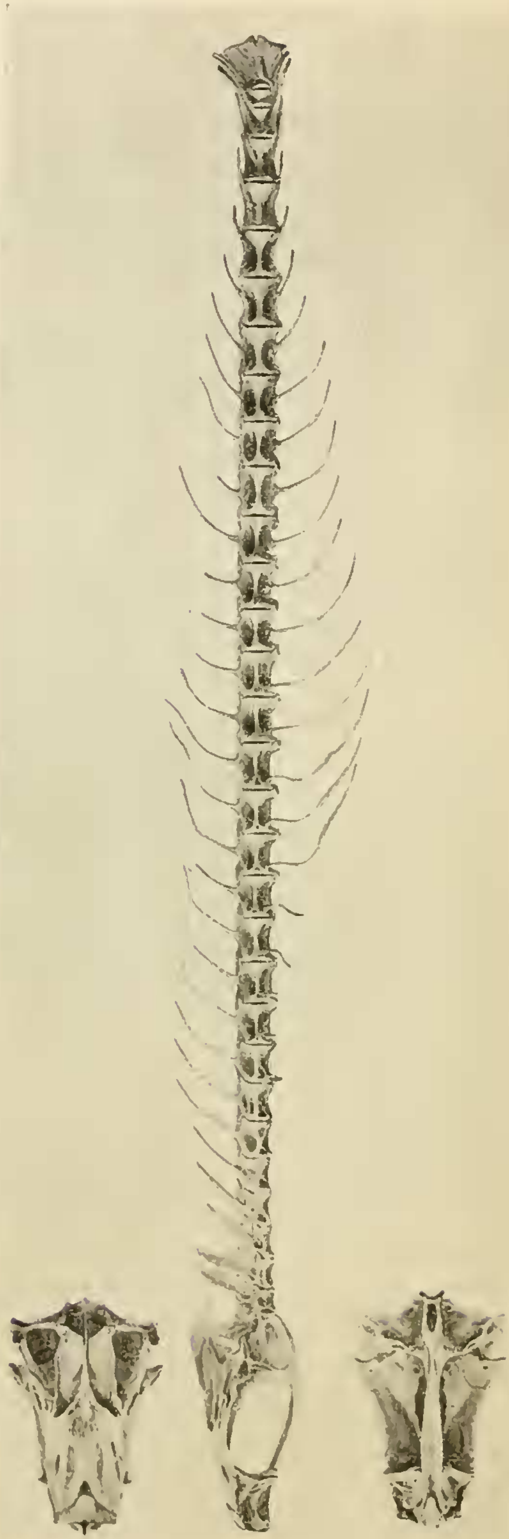


Fig. X. Skeleton of *Grammatorcynus bilineatus.* 3/5.

culating facets of the exoccipitals are nearly horizontal processes not united at the middle, they project backward over the condylar facet. The neural process of some anterior vertebrae is noticeably broad.

Stomach coecal, rather short, with about nine longitudinal folds inside. Pyloric portion descending, short, and thick walled, with about five longitudinal folds inside. Duodenum obliquely descending. Pyloric coeca short, numerous and branching. These are more or less grouped into several clusters, chiefly arranged on special tubular outgrowths. Posterior into the duodenum the intestine is nearly straight. The liver is three-lobed, the middle lobe shortest, while the right lobe is longest. Ureters are united at the posterior end of the blended kidneys. Urinary bladder small, with a short dorsal median septum, near the anterior end. Air-bladder well developed.

The vulgar name ot this fish is kusarah in Ryukyu, meaning perishable, as the fish decomposes very quickly. The fish is said to be inferior in taste. Specimens examined were from the Marshall and Ryukyu Islands. Most of them are about thirty cm. in the total length.

Genus **Cybium** Cuvier.

Cybium, Cuvier, 1829, Günther, 1960.
Scomberomorus, Lacépède, 1802; Dressler & Fesler, 1889; Jordan & Evermann, 1896.

Body elongated and more or less compressed, covered with thin small scales, or sometimes naked outside of the corselet. Top of the head more or less convex. Posterior nostrils elliptical. Mouth large, upper jaw extending beyond the hind margin of the eye. Posterior end of the upper jaw rounded, and its lower margin nearly straight, being formed by the premaxillary only. Teeth large, compressed, and curved inward with trenchant edges. Gill-rakers few and short. Dentigerous ossicles on the branchial arch are in two rows. Skull elongated, with its dorsal surface somewhat flattened, and entirely covered with muscles. Occipital crest low, but continuous to the median ridge of the frontals. Vomer projects as an oval flat process, and is covered with villous teeth. Pylorus long and slender. Pyloric coeca dendritic, more or less coarse, and open to branches arranged on both sides of pyloric tubules.

Fishes belonging to this genus are generally large, and move in shoals, inhabiting temperate and tropical regions, where industries of some importance are established upon them. They are generally good in taste, the flesh being fatty and delicate in structure.

In 1803 LACÉPÈDE created a new genus *Scomberomorus* for a fish of this genus, by examining an inaccurate copy of a sketch by PLUMIER, which represented the two dorsals as if they were connected together. But afterwards LACÉPÈDE found that his *Scomberomorus plumierii* was a synonym for *Scomber regalis* BLOCH; so that he withdrew the genus afterwards, and omitted it in the index of his work. Moreover the following diagnosis of the genus written by LACÉPÈDE is quite inappropriate for any fish of the Cybiidae. The diagnosis is written as follows:—

"Une seule nageoire dorsale; de petites nageoires au-dessus et au-dessous de la queue; point d'aiguillons isolés au-devant de la nageoires du dos".

I have found the five following species in our waters. Though JORDAN and RICHARDSON (29) mention the name of *C. kuhli* in their catalogue of Formosan fishes, I was unable to find the species.

Key to the Japanese species of the genus *Cybium*.

Lateral line simple, air-bladder present.
- Pectorals pointed, many transverse bands on the body .... *C. commerson.*
- Pectorals large and rounded, indistinct spots in one or two rows............ *C. chinense.*

Lateral line with numerous fine branches, air-bladder absent.
- Tongue toothed, lateral line slightly undulating.
  - Height of the body nearly equal to the length of the head, second dorsal long. .... *C. guttatum.*
  - Height of the body much greater than the length of the head. ...... *C. koreanum.*
- Tongue naked, lateral line with a marked curve. .... *C. niphonium.*

Cybium commerson (Lacépède).

Yokoshimasawara, totuh (Taiwan), ushisawara.

Fig. 36.

Scomber commerson, Lacépède, Hist. Nat. Poiss., II, 600, Pl. 20, Fig. 1, 1800.
Cybium commersonii, Cuvier, Regne Anim.; Rüppel. Atl. Fische, 91, Taf. 25, Fig. 1, 1828; Cuv. & Val., Hist. Nat. Poiss., VIII, 165, 1831; Rüppel, N. W. Fische, 41; Günther, Cat. II, 370, 1860; Day, Fish. India 255, Pl. LVI, Fig. 5, 1875-78; Klunzinger, Fisch. Roth. Meer, 112, 1884.
Cybium multifasciatum, Kishinouye, Sui. Gak. Ho, I, 9, Pl. 1, Fig. 3. 1915.

D. 17, 15, 9. A. 14, 9. Gill-rakers 1+2. Vert. 20+24.

Body elongated, fusiform, highest near the middle part, that is at the origin of the second dorsal, and nearly rounded in cross-section. Snout long. Minute scales are found all over the body. Lateral line undulating, making a marked curve behind the second dorsal. Scales on the lateral line are about 230 in number. Teeth in jaws short, triangular, nearly straight, much compressed, and very minutely serrated as in *Acanthocybium*. There are about 30 in the upper and 20 in the lower jaw. Teeth on the vomer and palatines are very minute, granular and indistinct, as KLUNZINGER rightly remarked "viele rauhe Plättchen." The intestine is very long, and bent four times. Air-bladder present. Lateral keel of the caudal peduncle rather low. Back greyish blue, and the belly silvery. On side of the body about fifty transverse bands which fade gradually towards the ventral median line. In young specimens these bands are represented as elongated dots on the sides and very few in number. With the growth of the fish, these markings elongate and increase in number. Mouth cavity nearly colourless.

The flesh is said to be fatty but firm, and is superior in taste to that of our common seerfish, *Cybium niphonium*. Spawning season seems to be in spring, when they visit the coast of Taiwan in schools. In July immature fishes of about ten cm. are found in Taiwan, and immature fishes of about twenty cm. in the markets of south China in autumn.

The first specimen caught in Japan proper and identified as belonging to this species was found by Mr. YOZO NAKAJIMA, at the northern coast of Yamaguchi-ken, and was sent to me for identification, in Dec. 1914. The fish measured 126 cm in the total length, and 20 kg in weight. According to Mr. NAKAJIMA this species is caught on the Japan Sea coast of Yamaguchi-ken from October to January, in fixed seines or gill-nets for *Seriola quinqueradiata*. Only two or three are caught in a haul. Here they seem never to come to a ground shallower than 30 metres.

This species is abundant on the west coast of Taiwan in winter and spring. It is very widely distributed in the Indo-Pacific region, being known in New Guinea, East India, India, Red Sea, Cape of Good Hope, Samoa, and Australia. Mr. K. MIYAGAMI collected many immature specimens in autumn in southern China, and a few stragglers are caught on both sides of the Strait of Chosen in autumn and winter. This species is remarkable for migrating to the north in cold months and to the south in warm months. Large schools are hauled in Taiwan in a seine or caught with troll-lines, set nets, or drift nets. Caught abundantly on a calm day after a strong gale.

Cybium chinense Schlegel.

Inusawara, aosawara, hasawara, hoteisawara, kusamochi, okisawara, uke, ushisawara.

Figs, 34, 40.

? *Scomber sinensis*, Lacépède, Hist. Nat. Poiss. III, 23, 1802.
? *Cybium chinense*, Cuv. & Val., VIII, 180, 1831.
Cybium chinense, Schlegel, Fauna Japon., Poiss, 100, Tab. 53, Fig. 1, 1850; Kishinouye, Sui. Gak. Ho, I. 11, Pl. 1, Fig. 5. 1915.
Scomberomorus chinensis, Kishinouye, Zool. Mag. Tokyo, XX, 1. Pl. 2, Fig. 1, 1908.

D. 16, 15, 8. A. 16, 7. Gill-rakers 2+9. Vert. 18+22.

Body elongated, laterally compressed, and becomes deep rather suddenly behind the nape in some forms, probably the male. Head large, pointed, and concave in the dorsal outline. Snout long. Teeth in jaws lanceolate, trenchant, and curved inward, about 20 in the upper and about 15 in the lower jaw. Villiform teeth on the vomer, palatines, and the tongue. First dorsal rather low, becomes almost invisible in the posterior part, being hidden in the groove. Caudal very large and powerful. Pectorals remarkably large and rounded. The lateral line has a marked curve under the posterior part of the first dorsal, and is undulating in the caudal portion, where the lateral line is found below the lateral median line. The intestine is bent a little near the middle point. Abdominal cavity rather high.

Back greenish blue, belly silvery, and fins mostly blackish. Ventrals and the anal are blackish at the margin, but the anal finlets are quite colourless. Iris is silvery or washed with light brown.

This species attains a big size, being the largest one among our scerfishes. A fish of 2 m in length, and 80 kg in weight is recorded. Too fat, and more or less inferior in quality. Not sought after with a special fishing apparatus. Sometimes unintentionally caught in nets for other fishes. Rather abundant on the southern coast of Chosen, two or three dozens of this species being often caught on an autumn day, in a pound-net erected at a depth of about 20 m; and in the fish-market of Fusan gigantic forms of this species attract visitors' eyes.

On the Pacific coast the northern limit of the distribution of this species is found in the east off Chiba-ken, and in the Japan Sea off Akita-ken.

Chiefly found on the coast of the southwestern part of our country, in Kyushyu and Chosen. More or less abundant in the Japan Sea. Not found in the clear warm water of the Kuroshiwo. It is said that this species is often found at a spot where two currents of water meet in violent commotion, and this species seems to have habits similar to spearfishes.

Whether *Scomber sinense* LACÉPÈDE and *Cybium chinense* CUVIER are synonyms of this species is not quite certain, as their descriptions being founded on a Chinese picture are very poor; but so far as we know there is no other species in the oriental waters than the present one which has the lateral line bent beneath the first dorsal. Therefore the Chinese picture on which these species were founded will probably represent this species.

Cybium guttatum Cuv. & Val.

Kahpah.

Fig. 61.

? *Scomber guttatus*, Bloch, Schneider, 23, Taf. 5, 1801.
Cybium guttatum, Cuv. & Val., Hist. Nat. Poiss. VIII, 173, 1831; Günther, Cat. II, 371, 1860; Day, Fish, India, 255, Pl. LV, Fig. 1, Pl. LVI, Fig. 4; Cantor, Malay Fish., 111, 1849; Kishinouye, Sui. Gak. Ho, I, 379, 1916.

D. 16, 19 or 20, 8 or 9. A. 21, 8. Gill-rakers 2+8. Vert. 21+30.

Body elongated, laterally compressed, and nearly naked outside of the corselet. Caudal portion long and broad. Second dorsal, anal, and the caudal well developed, but the pectorals are small. Teeth in jaws sharp, about 17, minute teeth on the vomer, palatines, and the tongue. Lateral line is nearly straight with a slight bend, a little before the caudal keel. Numerous short branches are found in the anterior half. They are oblique, closely set, and are longer towards the nape, diverging backward. The scales on the lateral line are about 170.

The right lobe of the liver is large, while the middle lobe is short and narrow. Intestine is slender with a loop at the middle. The inner wall of the stomach has about twenty longitudinal folds, half the number of which are smaller and alternate with the larger. Pylorus descending, stump at the distal end, and communicates with the duodenum by a very narrow opening. The duodenum is nearly as long as the pylorus, wide at the fore end, with one anterior pyloric canal and another large posterior canal. Air-bladder wanting.

Body silvery greyish with several rows of dark spots on the side. Two dorsals, dorsal finlets, and the caudal are black. Anal and anal finlets are colourless.

Specimens examined measure about 60 cm.

Widely distributed in the Indo-Pacific region and also in Australian waters. Rather abundant in Taiwan.

Cybium koreanum Kishinouye.

Hirasawara.

Fig. 35.

Cybium koreanum, Kishinouye, Sui. Gak. Ho, I, 11, Pl. 1, Fig. 6. 1915.

D. 14, 19–21, 9. A. 18–21, 7. Gill-rakers 3+10. Vert. 20+26.

Body very deep, deeper than the length of the head, and broadest at the line connecting the origin of the second dorsal and that of the anal. Snout short. Small scales are found in the corselet, lateral line, and round the base of the fins. They are, however, chiefly concealed under the skin, so that the body seems to be entirely naked. Teeth in jaws sharp, elongated, 16–19 in the upper, and 13–15 in the lower jaw. Villous teeth on the vomer, palatines, and the tongue. Two gill-rakers are found on the second branchial arch. The lateral line runs nearly parallel to the dorsal outline of the body, with slight undulations. Many branches on both sides of the anterior half of the lateral line are quite similar to those found in *C. guttatum*. The ventrals are very small, but the other fins are well developed, especially the second dorsal, anal, and caudal. Intestine very long, bent more than four times. Short blind process at the end of the slender pylorus. Air-bladder wanting. Abdominal cavity very low, compared with that of other seerfishes. The inner wall of the stomach has about 15 longitudinal folds. Four pyloric tubes from the duodenum, of which the second is the longest.

Occipital crest very high, gradually ascending behind. Hyoid bones, clavicle, and hypocoracoid very broad. One auxiliary intermuscular bone in the occipital region. In some caudal vertebrae we find a lateral median groove on each side, so that their cross-section is more or less octo-radiate.

The whole body shines brilliantly with a metallic lustre. The back is greyish blue, and the belly silvery. There are three or more longitudinal rows of small greyish spots along the lateral median line. Fins blackish, ventrals and anal finlets excepted.

It is remarkable that this fish spawns at the mouth of Daidōkō, near Chinnanpo in July, and the immature fish is caught in stow nets near the port, in August and September. Grows to a length of more than one and a half metres, and about fifteen kg in weight. Matures when the fish is about 2.25 kg in weight and 75 cm in length. At Chinnanpo the water is turbid, of a brownish colour, and in warm seasons its density at 15° C is 1.0126—1.0164 near the surface, and 1.0166—1.0182 near the bottom.

So far as we know the distribution of this species is limited to the west and south coasts of Chosen.

Caught in summer and autumn with drift nets or in pound-nets. The fishery of this fish in Daidōkō was begun by Japanese fishermen since 1917.

It feeds on sardines, anchovies and shrimps.

Very nice food fish; but becomes inferior in the spawning season.

Cybium niphonium Schlegel.

Sawara, sagoshi.

Figs. 6, 9, 32, 41.

? *Cybium niphonium*, Cuv. & Val., Hist. Nat. Poiss., VIII, 180, 1831.
Cybium niphonium, Schlegel, Fauna Japon. Poiss., 101, Tab. 53, Fig. 2; Kishinouye, Sui. Gak. Ho, I, 10, Pl. 1, Fig. 4, 1915.
Scomberomorus niphonius, Tanaka, Fish Japan, I—X, 154, Pls. 42, 44, 1912.

D. 19, 15, 9. A. 15-17, 8. Gill-rakers 3+9-10. Vert. 22+28.

Body slender, elongated, and compressed, covered with such minute scales that they are not stripped before cooking. Corselet indistinct. First dorsal very long, and its dorsal outline is of very slight slope. Pectoral concave at the inferior posterior margin. Lateral line undulating, and has a marked curve below the second dorsal. Many small branch-canals are found on both sides of the lateral line, but they are not so distinct as in *C. guttatum* and *C. koreanum*. Teeth in jaws lanceolate, curved, and trenchant, about 25 in the upper and about 20 in the lower jaw. They are a little smaller than those of other species. Villous teeth on the vomer and palatines, but none on the tongue. Only one gill-raker on the second gill-arch.

The right lobe of the liver is longer than the others. The inner wall of the stomach is provided with about 12 longitudinal folds. Intestine slender, straight, without any loop. No blind sac to the pylorus. Duodenum saccular, more or less flattened, and wide. There are about six pyloric tubes. The tube opening just behind the pylorus is longest. No air-bladder.

The whole body shines with a metallic lustre. The back is light greyish blue, washed with green, and the belly silvery. In a living fish we observe a purplish shade. Seven or more longitudinal rows of greyish spots are found on each side of the body. Some anterior spots in the median row are often connected together. The male fish is said to be darker in colour than the female. Pectorals, two dorsals, and the caudal are blackish. Ventrals and the anal are nearly colourless. Immature fish of about 7 cm lacks markings. They are broader, compressed and have a longer head than the adult.

Grows to a length of about 1 m. and 4.5 kg in weight. A fish under one half metre long, and about one kg in weight is generally immature, and is called "sagoshi." A fish under about two kg in weight is called "kozawara" by fish-mongers.

This species is a good and valuable food-fish, caught all the year round, and especially abundant in spring, when the fish spawns. Spawning season is from April to May. The ripe ovum is very large, about 1.5 mm in diameter. The larval fish is remarkable in having a large head with well developed strong teeth in jaws. Immature fish of about 3 cm are found in April and May. They grow to 10—20 cm in winter. Those immature fish are found in shallow waters and are caught in drag seines for sardine.

Ovarian ova do not mature at the same time; but here and there some ova become large and transparent, and assemble to the central cavity to be discharged.

Though wanting in the air-bladder this species has a rather wide range of vertical distribution, swimming near the surface of water in warm seasons, and descending to the deeper layer of waters in cold seasons. Geographically this species is widely and abundantly distributed in coastal waters (10—20° C, 1.022—1.024 in density) of our empire;—Hondo, Shikoku, Kyushyu, and Chosen, and also in waters of northern China. Most abundant in the middle part of the empire, especially on the coast of the Inland Sea, but becoming more scarce in the northern and southern parts. A few stragglers are sometimes found on the coast of Hokkaido. This species enters the Inland Sea and bays in the spawning season. It becomes very lean after spawning; but recovers its fattiness already in autumn. In summer and autumn the fish is often found near the surface, it leaps out of the water, but in the cold months it lives near the bottom. At the flood-tide the fish is more active and is said to pursue small fish violently, often tearing drift nets with force. Thus fishermen of some villages of Nagasaki-ken are said to use the drift net for this fish at the time of the ebb-tide only.

A fishery expert in Kagawa-ken estimated the number of ova spawned from an adult fish in a season to be 550,000—870,000.

In the migration to the Inland Sea the male fish is more numerous at the beginning of the season; but the female fish predominates near the close of the season. At this time the female fish may easily be distinguished from the male by the thick and swollen abdomen.

Caught with troll- or hand-lines, set-nets, drift nets, seines, pound-nets etc. Long lines are seldom used, as the fish are not easily induced by dead or inactive baits. When empounded in pound nets at night the fish seem to try to escape through the meshes at the bottom.

In the Inland Sea trollers expect good catches within the two hours before and after the ebb-tide, especially at dawn. In this sea the fish feeds principally on the sand-eel.

A jaw bone of this fish was found in a shell-mound in Chiba-ken, which proves that the prehistoric people in our islands also caught this fish. However the fishery of this fish seems to have developed very slowly. The name is not mentioned in very old literature, such as the "Yengishiki" and the "Manyoshyu", though many other common kinds of fish are enumerated.

Late in November, 1902, a fisherman of Niihama, Yehime-ken, caught about fifty adult sawara with drift-nets. This untimely catch caused much astonishment. Generally adult sawara leave the Inland Sea soon after spawning, latest at the end of June.

From a recent inquiry of the Experimental Fishery Station of Kagawa-ken, it became clear that this species comes to the Inland Sea again in autumn, though not so abundant as in spring. However, it is thought that the fishery in autumn in the Inland Sea will be remunerable to open-boat drifters.

Genus **Sarda** Cuvier.

Sarda, Cuvier, 1829; Jordan & Evermann, 1895.
Pelamys, Cuv. & Val., 1831; Günther, 1860.

Body elongate, but rather short and compressed in young specimens. Scales minute, and a small corselet more or less distinct. The caudal keel is thick and naked. Teeth in both jaws are large, compressed, and strongly curved inward, but not trenchant. Near the anterior end of the lower jaw, the row of teeth is bent inwards and approaches the symphysis. Vomer is toothless, but a single row of rather strong and curved teeth on the palatines. Tongue also toothless. Many dark, longitudinal, more or less oblique stripes are found in the dorsal part of the body. Vertebrae of the caudal peduncle have lateral keels. Voracious fish of rather small size in subtropical and tropical waters of both Pacific and Atlantic Ocean. Pelagic.

Sarda orientalis (Schlegel).

Hagatsuwo, hohzan, kitsunegatsuwo, sabagatsuwo, shimagatsuwo, sujigatsuwo, tohzan, etc.

Figs. 11, 17, 33, 42.

Pelamys orientalis, Schlegel, Fauna Japon. Poiss., 99, Tab. 52, 1850; Günther, Cat. Brit. Mus. II, 368, 1860.
Sarda chilensis var. *orientalis*, Steindachner & Döderlein, Beitr. z. Kennt. d. Fisch. Japan., III, 11, 1883.
Sarda orientalis, Kishinouye, Sui. Gak. Ho, I, 12, Pl. 1, Fig. 7, 1915.

D. 19, 15, 7–8. A. 15, 5–6. Gill-rakers 4 + 9. Vert. 25 + 20.

Body elongated fusiform in adult specimens, but rather short and compressed in young specimens. Mouth wide, maxillary reaching beyond the orbit, with large curved and compressed teeth. Teeth in jaws are more or less unequal in size. About 16 in the upper, and 10–13 in the lower jaw. Groove in the skin from the corner of the mouth is present, as in the tunnies. Posterior nostril is a mere slit. Scales minute. Lateral line undulating slightly, and has a peculiar, wave-like bend over the pectoral fin.

Stomach long, with more than twenty longitudinal folds. Intestine nearly straight, boundary of the rectum indistinct. Pylorus descending with a few longitudinal folds inside, and rather narrow.

Liver consists of three slender lobes, of which the two lateral lobes are very long and nearly equal in length, while the middle one is short.

Myotomes are strongly folded, so that in the cross-section of the lateral muscle we count nearly as many rings as in the same of tunnies. The median wedge-shaped portion of the lateral muscle is reddish, and the red portion becomes thicker towards the tail. On the surface of the last myotome we cannot find a tendon.

Skeleton porous and rather weak, and much resembling to the type of the Cybiidae. The vertebrae of the caudal peduncle are provided with lateral keels, each of which is divided into two, anterior and posterior portions. Two auxiliary intermuscular bones are found on the exoccipital,—one on the dorsal wall of the foramen magnum, the other a little forward. At the dorsal part of the clavicle the anterior pointed process is widely separated from the posterior lamellar part.

Grows to a length of about 80 cm and to a weight of 1.5–3.0 kg.

Flesh is rather soft, and inferior in quality. Generally this species is not specially sought after, except in Kyushyu, but is caught as an adjunct in fisheries of the mackerel, bonitos, scuds, etc. It is said that in Kyushyu a few pound-nets are specially built for the capture of this species.

This species lives rather near the surface of the coastal waters, and sometimes makes large shoals. It bites eagerly on a bait, natural or artificial, hence it is easily caught with trolling lines.

Found in the southern parts of our waters, both on the Pacific as well as on the Japan Sea coast, especially abundant in Kyushyu. Many years ago, an immature example was caught in a drag-seine on the Pacific coast of Aomori-ken. The Hawaiian species of *Sarda* seems to be the same as the Japanese species, but the Californian seems to belong to the Chilian species.

Many authors have confounded this species with an allied species from the Pacific coast of South America; but the difference between them is quite evident. As SCHLEGEL rightly remarked, the pectorals are smaller in *Sarda orientalis*, and not only these fins but the other fins are also smaller. Moreover the number of gill-rakers is 9 + 17 in *Sarda chilensis*, and the number of vertebrae is 22+22. The dark stripes in the back are fewer, and more oblique in *S. chilensis*, and much wider apart than in *S. orientalis*.

Genus **Gymnosarda** Gill.

Gymnosarda, Gill, 1862.

Body long, fusiform with a large head. Mouth large, but the maxillary does not reach beyond the orbit. Eyes large. Scales in the corselet elongated, and concealed under the skin. Outside of the corselet and the base of the fins the skin is entirely naked. Lateral line undulating. Teeth in jaws large, curved, and nearly conical. Villous teeth on the tongue and palatines, but the vomer is toothless. Caudal portion very slender with a well developed keel on each side.

First vertebra is very short. Cross-section of caudal vertebrae is more or less cruciate, but the lower end of the perpendicular limb is always bipartite. Anterior precaudal vertebrae with three ventral grooves. In external appearance fishes of this genus are closely related to tunnies.

Pelagic fish of voracious habit, and of somewhat large size in the littoral waters of the tropical region, chiefly Indo-Pacific; but a species is recorded from European waters,—the Mediterranean and the North Sea. In spite of great differences in external characters, as well as in the internal anatomy, many authors confounded this genus with the genera *Katsuwonus* and *Euthynnus* of the Katsuwonidae.

Gymnosarda nuda (Günther).

Isomaguro (Ogasawara Is.), tokakin (Ryukyu Is.).

Thynnus (Pelamys) unicolor, Rüppel, N. W. Fisch., 40, Taf. 12, Fig. 1, 1838.
Pelamys nuda, Günther, Cat. Brit. Mus. II, 368, 1860; Klunzinger, Fisch. d. Roth. Meer., 110, 1884.
Gymnosarda nuda, Kishinouye, Sui. Gak. Ho, I, 13, Pl. 1, Fig. 8, 1915.

D. 14, 13, 7. A. 12, 6. Gill-rakers 2+10. Vert. 19+19.

Body fusiform, entirely naked outside of the small corselet. Head comparatively large and the caudal peduncle very slender. As the scales of the corselet are concealed under the skin, small wrinkles are found around the pectorals, and several longitudinal furrows on both sides of the dorsals. Lower jaw broad. Teeth in the upper jaw are 18–23, and in the lower jaw 10–16.

Lateral line runs parallel to the dorsal outline of the body, nearly to the twelfth spine of the first dorsal. Below the spine the line is bent downward. Behind the vertical from the first dorsal finlet, a few undulations in the line. Scales of the lateral line are also concealed under the skin, and on both sides of the pored scales we find two or three rows of minute scales. The lateral keel of the caudal portion is also covered with minute, elongated scales. The third spine of the first dorsal is longest and thickest, though RÜPPEL reports that in his specimens the second spine is the longest. Air-bladder large and thick-walled, though RÜPPEL denies its presence. Pyloric coeca form a conspicuous mass in the abdominal cavity as in other forms of the Cybiidae, so that it is strange that they escaped the eyes of RÜPPEL, but the fact that the mass of the coeca is enormously developed deceived the naturalist, probably the mass was taken as a part of the liver or other organs, as KLUNZINGER (49) remarked in his work.

Skeleton firm and strong. The number of vertebrae is very small, compared to that of the species of *Cybium*. Skull flat and broad. Anterior half of the frontals is provided with many oblique ridges, and covered directly with the skin. Posterior margin of the preopercle is a little undulating. Dorsal anterior margin of the opercle is slightly concave. Inner limb of the subopercle is large. First vertebra is very thin and its neural process is free from the centrum. Anterior precaudal vertebrae want the parapophyses, and the lateral keel of the caudal peduncle is narrower than the diameter of the centrum. The last haemal process is coalesced to the fan-shaped hypural bone. Cross-section of vertebrae is not exactly cruciate in most of them, but more or less sex-radiate. Haemal arch is formed from the eleventh vertebra, and haemal spines of some length are found in precaudal vertebrae. Inter-muscular bones are very numerous, being found to the 29th vertebra.

Colour is said to be dark bluish to violaceous at the back, and greyish white at the belly. Top of the head and the anterior end of the lower jaw are greyish. Fins are black or greyish, leaving the tip of the second dorsal and anal colourless.

It is told that the fish attains the big size of about 240 cm with a weight of 80 kg; but fishes now commonly caught at the Ogasawara Islands are 100–150 cm in length, and 20–30 kg in weight.

Known from the tropical regions of Indo-Pacific waters. Caught with harpoons, hand-lines, and trolling lines at the Ogasawara and Ryukyu Islands

Voracious fish, resorting to the rocky bottom of coastal waters in small schools of tens or scores, devouring *Caesio*, *Decapterus*, etc. Not found in off-shore waters. Caught at grounds about 20–200 m off, with hooks dressed with live baits. Bites hooks readily in the twilight. When there is no tidal current the fish is easier caught. A better catch is expected in the spawning season, May and June, though it is caught all the year round. Some condemn the flesh of this fish as soft and unsavoury, but others commend it as delicious. This difference of opinion is perhaps due to the difference of season in which the fish was tasted. KLUNZINGER (49) says "selten einzeln, in hohen Meeren, meist tief, kommt selten herauf. Frisst als Lockspeise Clupeiden und kleine Sphyränen. Fleisch geschätzt."

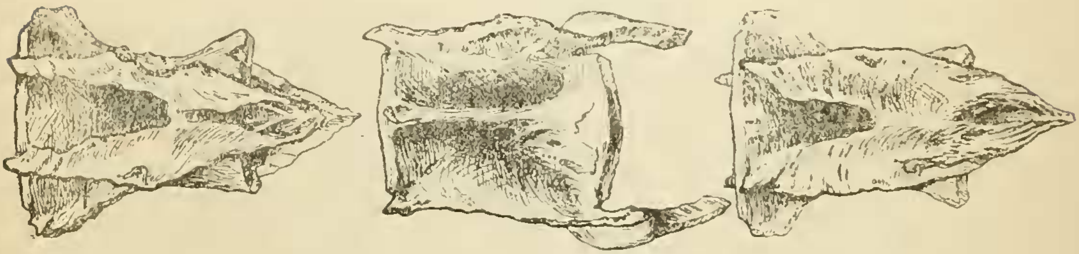


Fig. Y. A caudal vertebra from a shell-mound of Ogido. 7/9 nat. size. From left, dorsal. lateral and ventral views.

Recently Mr. AKIRA MATSUMURA of the Anthropological Institute of our University sent me for identification a large vertebra obtained from a shell-mound in Ryukyu. The vertebra is closely allied to the 31st vertebra of the present species, but not exactly, differing in the shape of the lateral keels, and the neural and haemal grooves.

Order PLECOSTEI Kishinouye.

Plecostei, Kishinouye, 1917.
Thunnidae, Kishinouye, 1915.
Thunninae, Starks, 1910.

Group of teleostomatous fish, having a cutaneous vascular system, connected with the vascular plexus developed as sheets in the lateral muscle.

Portions of the lateral muscle surrounded by these sheets of the vascular plexus are situated on both sides of the vertebral column, and are dark red, nearly black in colour. Another peculiar vascular plexus is developed on the inner side of the liver or in the haemal canal. Moreover the circulation of blood in the liver is especially well developed.

Thus this group of fish is distinctly defined from the other forms of the Teleostomi, and comprises the most highly specialized forms of fishes. There is no doubt that they are descendants from the Acanthopterygii, among which they should have been classified. They are most closely allied to the genera *Sarda* and *Gymnosarda* of the Cybiidae.

The body is well adapted for swift locomotion, being plump, pointed at both ends, and smooth at the surface. Caudal peduncle very slender, but with broad lateral keels. Head triangular, nearly flat at the top. Snout shorter and the mouth smaller than in the Cybiidae, the upper jaw scarcely reaching the vertical from the middle of the eye. The posterior part of the external margin of the upper jaw is not straight, but bent downward, due to the overlapping of the maxillary over the premaxillary. Posterior end of the upper jaw is straight, due to the form of the supplementary bone. The anterior nostril is a mere point, and the posterior nostril a transverse slit. Scales large and thick in the corselet, and those behind the eyes are thick and elongated. Scales are ctenoid at the margin but smooth at the surface. Opercular region is entirely naked. Corselet is covered with a thick membrane of strong connective tissue, to protect the thick part of the peculiar cutaneous vascular system.

Fins are well developed with thick spines and strong fin-rays. In the first dorsal the first spine is not inferior in size and thickness to any succeeding spines, and the posterior side of the dorsal outline of the fin is concave. The caudal fin is firm and very widely forked, more or less lunate in shape.

Gill-rakers are long and fine, and are developed on both sides of branchial arches. Abdominal cavity is narrow and depressed, as the ventral processes of the precaudal vertebrae are well developed, consequently the hypaxial portion of the lateral muscle in the precaudal portion is very thick (Figs. 18, 19). Portions of the lateral muscle on both sides of the vertebral column are coloured dark red or blackish. These portions are called "chiai" in Japanese, and each dark red portion is thick at the anterior end, tapering gradually towards the posterior end. The chiai portion is soft and poor in taste, and contains about seven to fifteen times as much blood as the other portion, estimating from the colour.

Pylorus short, descending, runs along the inferior side of the stomach. Duodenum receives at the posterior side five or six dendritic canals carrying the tufts of pyloric coeca, and in bonitos two short tubes on the anterior side as well. These dendritic tubes greatly vary in length. Each terminal branch of these tubes ends with a tuft of coecal outgrowths of nearly equal size, and yellowish in colour. Each group of these tufts is covered with a membrane, and the whole mass of these tubes is covered with a thick membrane to form a compact mass. In these tubes we find a half digested mass of food, but in the yellow tufts we have not found it yet.

Myotomes at the surface of the body are bent with acute angles at 5 points, so that we find more than ten concentric circles in the cross-section of the lateral muscle in each quadrant. There are three myotomes in the cephalic region, and generally we find an auxiliary intermusclar bone between the last two. Myotomes in the caudal peduncle seem to have been reduced in number. Moreover the terminal tendon of these myotomes are well developed, and may be distinctly seen at the outer surface of the muscle, when we remove the skin.

The vascular system is very complicated and variable in different members of the group. Besides the cutaneous vascular system we find many peculiarities. It is remarkable that in the ancestral forms of tunnies the posterior cardinal vein does not pour directly into Cuvier's duct. In these tunnies the principal veins uniting with the Cuvierian ducts are two large cutaneous veins carrying blood from the dark red portion of the lateral muscle, and the anterior jugular veins. The posterior cardinal vein is insignificant and communicates with lateral commissures at the caudal peduncle to the cutaneous veins mentioned above. In these forms hepatic portal veins form a massive plexus on the axial side of each lobe of the liver. In more advanced forms, however, the posterior cardinal vein is well developed and united with the right Cuvierian duct. In these forms the venules flowing downwards from the dark red portions collect to the comparatively spacious haemal canal, and there they are divided into many short parallel transverse canals, which fill up the canal entirely, forming a solid mass in it. In still more modified bonitos, the cutaneous veins do not unite directly with the Cuvierian duct, but form hepatic portal veins. In bonitos the vascular plexus is also found in the haemal canal. Blood vessels in the air-bladder belong to the visceral vascular system.

In primitive tunnies the kidneys are more or less ring-shaped, just behind the head, and around the pharyngeal muscles. In the other tunnies the kidneys are produced more or less behind, and in bonitos they are elongated nearly to the end of the abdominal cavity. Posterior portions of the kidneys lie chiefly on the roof of the abdominal cavity but, in the haemal canal too we find a continuous or sometimes small discontinuous masses of a kidney-like brownish substance with minute black spots.

Skeleton firm, solid, and comparatively light. Skull firmly consolidated. The dorsal surface of the skull is entirely covered with the lateral muscle and there we find paired non-ossified portions, except in the genus *Auxis*. On the ventral side of the skull we find many deep grooves for the insertion of opercular muscles. The posterior end of the parasphenoid is more or less tubular. Subcranial cavity is very high. Lower piece of the postclavicle is not flat, the broad proximal part making nearly a right angle with the narrow distal part, and these two parts are in two different planes. The distal part is very short in many cases. Clavicular ligament is inserted in the first vertebra not to the skull.

Vertebrae are compact and rich in grooves and ridges, so that they are light and firm. The total number of vertebrae is always 39, except in the genus *Katsuwonus* which has 41. They differ from each other in form, processes, etc, in different parts of the vertebral column. Neural and haemal processes are more or less laterally compressed. The first neural process is remarkably feeble.

Fishes of this order seem to have their own temperature, more or less higher than the temperature of the water in which they live. They are voracious, pelagic fish, swimming very fast, and feeding on small fish, calamaries, and medium sized plankton. Found in temperate and tropical seas. They spawn in off-shore grounds and grow there. They are very energetic and powerful, therefore specially long and strong implements are required for catching them.

Key to the families of the order Plecostei.

Body wholly covered with scales, second dorsal and anal high, vertebrae 18+21, transverse process present, 1st vertebra short, anchylosed to the skull, alisphenoids meet at the ventral median line, air-bladder generally present..... *Thunnidae*.

Body naked outside of the corselet, second dorsal lower than the first, vertebrae generally 20+19, some intermuscular bones are divided into two, distal and proximal, epihaemal spine developed between the centrum and the haemal arch in most vertebrae, network of haemal processes well developed, air-bladder wanting. .... *Katsuwonidae*.

Family THUNNIDAE Kishinouye.

Thunnidae, Kishinouye, 1918.

Body plump, wholly covered with scales, which differ in size and form in different parts of the body. Corselet well developed, but its boundary is not distinct. The lateral line has a peculiar curve above the pectorals. Teeth rather feeble. Single series of small conical teeth in both jaws. They are sharp and curve inward. Villiform teeth on the vomer, palatines, and pterygoids. Many dentigerous calcareous plates are found on the palate. The denticles on these plates are quite similar to those found on the vomer, palatines and pterygoids. Thus the roof of the mouth-cavity is quite rough, contrary to the nearly smooth roof in the Katsuwonidae. Three lobes of the liver subequal. Intestine rather long, with three folds. Pyloric tubes developed only on the posterior convex side of the duodenum. Pyloric coeca heteroclitic, irregular in size. Those found at the distal end being longer and thicker than those at the proximal part. This heterochrony is more marked in primitive forms. Rectum short, it has nearly the same diameter as the preceding part of the intestine. Air-bladder present, except in *Neothunnus rarus*.

Cutaneous blood-vessels above and below the lateral median line are united both at the anterior and posterior ends, and are connected by short horizontal vessels with the chief blood-vessels in the haemal canal at the caudal peduncle. The cutaneous veins are large and unite with the Cuvierian ducts directly or with the cardinal vein. Each of the paired cutaneous arteries arises just behind the pharyngeal muscles or somewhat behind it, runs backwards and downwards behind the root of either the third or fifth rib, and is divided into two nearly parallel branches, a little before it comes to the surface of the muscle, between two consecutive intermuscular bones. The dark red portion of the lateral muscle is rather narrow, and meets the axial skeleton with a narrow neck or root in the hypaxial portion only.

Ligament in a deep median groove between the anterior end of the frontals is attached to the skin, anterior to the median foramen of the skull. This ligament is a characteristic of this family.

The transverse process of some precaudal vertebrae is broad, well developed. The first vertebra is greatly reduced in height and firmly anchylosed to the skull. Inferior foramen is small, and is found in the caudal vertebrae only. Number of vertebrae is constant, 39 in total, of which 18 are precaudal, and 21 caudal. The haemal canal is closed in the tenth or eleventh vertebra, i. e. near the middle of the precaudal region. Alisphenoids meet at the ventral median line. Anterior precaudal vertebrae, are broader than high. Roof of the mouth cavity is covered with numerous plates covered with villous teeth.

Many systematists put too much weight on the length of the pectorals, but it has little value in the classification.

Key to the genera of Thunnidae.

Cutaneous blood-vessels pass through the myotome of the fifth vertebra, surface of the liver striated with fine venules. . . . . *Thunnus.*

Cutaneous blood-vessels pass through the myotome of the seventh vertebra, surface of the liver not finely striated with venules.

- Posterior cardinal vein is not continuous with the Cuvierian ducts. Vascular plexus on the inner side of the liver. . . . . *Parathunnus.*
- Posterior cardinal vein is continuous with the Cuvierian ducts, vascular plexus in the haemal canal. . . . . *Neothunnus.*

Genus **Thunnus** South.

Thunnus South, 1845.
Thynnus, Cuvier, 1817; Günther, 1860.
Orcynus, Cuvier, 1817.
Germo, Jordan, 1888.
Albacora, Jordan, 1889.

Body plump, robust. The first haemal canal is closed in the tenth vertebra. Anterior haemal arches of the precaudal region are turned forward and narrow. Right side of the stomach receives an artery from the downward branch of the coeliaco-mesenteric artery. Two large branches of the coeliaco-mesenteric artery send their blood to the liver, and they are finely divided into plexus on the inner side of the liver. These plexus reunite into several arteries to the stomach, spleen, and intestine. The hepatic portal veins running along these arteries are also subdivided into plexus before entering the liver. The oesophageal artery is not well developed, and the coeliac arteries are branched from hepatic arteries. Cutaneous arteries branch from the dorsal aorta below the fifth vertebra and just behind the pharyngeal muscles. Arterial and venous plexus on the axial side of the liver.

Round the spots of emergence of the hepatic veins the liver consists of only, a thin sheet of venules the substance of the liver not being found in these spots. Thus the liver is thickest midway between the root of the hepatic veins and the attenuated margin of the liver. Vascular plexus on the axial side of the liver are also situated at the thin portions, and are surrounded by thick masses of the liver. Roof of the abdominal cavity is convex, at the anterior part. External wall of the air-bladder is uniformly thin. Kidneys ring-shaped.

Key to the Japanese species of the genus *Thunnus*

Pectorals very long, reaching to the second dorsal finlet, markings in the belly, when present, longitudinally anastomosing. .... *Th. germo.*

Pectorals not reaching to the vertical of the origin of the second dorsal, markings in the belly transverse, and constantly present. .... *Th. orientalis.*

Thunnus germo (Lacépède).

Tomboshibi, binchoh, binnaga, kantaro.

Figs. 20, 46, 52.

Scomber germo, Lacépède. Hist. Nat. Poiss. II. 598. III, 1, 1802.

Thynnus pacificus, Cuv. & Val. Hist Nat. Poiss. VIII. 133, 1831 ; Günther, Cat. Brit. Mus. II, 366, 1860.

Germo germo, Jordan & Seale, Bull. Bur. Fish. XXV, 175, 1905.

Thunnus alalunga ?, Kishinouye, Sui. Gak. Ho, I, 18, Pl. 1, Fig. 10, 1915.

D. 14, 14, 8. A 14, 8. Gill-rakers 9+18-19. Scales ca. 210.

Body rather slender, head and eyes comparatively large, caudal portion short. Scales rather large, about 210 in the lateral line. Pectorals sabre shaped, very long, reaching to the first anal finlet. Lower margin of these fins is a little concave at the proximal part. Height of the second dorsal is equal to or a little shorter than that of the first dorsal.

The roof of the abdominal cavity is remarkably convex. So the cavity is very narrow and the flesh very rich in amount. Three lobes of the liver are connected with each other by very narrow portions, and the lateral lobes are divided into many lobules at the margin, as well as at the inner side. On the outer side of the liver we find very fine parallel venules, covering nearly the whole surface of the liver. On the inner side of the liver bulbous and more or less conical masses of vascular plexus of both arterioles and venules are found.

Venules to the cutaneous vein are arranged in two alternate rows, and are more numerous than the arterioles. These venules pour to the inner side of the vein. Arterioles from the cutaneous artery are arranged in one row, and on the inner side of the artery (fig. 20). Venules are very minute and numerous, forming thick sheets in the lateral muscle, before pouring into the cutaneous vein. These venules form numerous small bundles by uniting just at the root. Each of the numerous branches from the cutaneous artery is minutely, divided as soon as it emerges from the main blood-vessels, and running along the venules supplies fresh blood to the dark red portion of the lateral muscle. The cutaneous artery originates just behind the pharyngeal muscle in the levels of the fifth vertebra and runs obliquely backward.

Air-bladder present, rounded at the anterior end, and its wall is rather thin. It is narrow, but long, running the whole length of the abdominal cavity. Kidneys of both sides are united to form a flat, ring-shaped body round the pharyngeal muscles. The ring-shaped kidneys are slightly prolonged backward. Ureters of both sides meet in a nearly straight line, thick at the junction. In this thick junction, we find a short longitudinal septum from the anterior wall. Posterior to this septum the ureters are joined to a median tube.

Skull rather narrow. Vertebral column more or less slender. Height of the vertebrae nearly uniform. Parapophyses well developed. Parapophyses of the ninth vertebra are almost horizontal as in the preceding vertebrae; but in the tenth vertebra the haemal arch is formed and is turned forward leaving only a little space between the centrum and the arch. In each of the following precaudal vertebrae the haemal spine is formed, and it is remarkable that it is nearly uniformly elongated. These precaudal haemal spines are remarkably longer than in other tunnies. The head of the second and third ribs is very thick, and the distal portion of these ribs is broad, thin, and gradually narrow. The part between the head and the broad distal portion is very narrow to admit the passage of the cutaneous blood-vessels.

The colour is blackish blue in the dorsal part, with a greenish lustre near the tail. Sides and belly are silvery. In young specimens, ca 60 cm in length, we find some five or six dark, irregularly longitudinal bands, running near the ventral median line. These bands are more distinct at the caudal region, and are more or less united in the form of irregular net-work. First dorsal nearly colourless, except the dusky border. Pectorals black, ventrals and the second dorsal are dusky, but the anal is nearly colourless. The dorsal finlets are dusky, washed with yellow, while the ventral finlets are more or less dusky. Iris silvery, tinted with light blue.

This species is rather small, a germon of ca 25 kg is rather rare and large. In southern California 8 kg fishes are said to be common, a fish weighing 20 kg is considered large. In Japanese and Hawaiian waters, fishes of ca 45 kg are said to be nearly maximum and rare.

Very widely distributed in both the north and south Pacific. Caught in large quantities on the Pacific coast of Hondo, but not yet found in the Japan Sea. Found in off-shore grounds only, never approaching the coast. This species is caught in our waters till about 43° N, off the south coast of Hokkaido. In spring the germon begins to migrate northward. In this northerly migration the germon precedes the striped bonito, but follows our common tunny (*Thunnus orientalis*). In winter the germon is found in the southern part of our waters, about 34° N. Found in water of 10–25° C in temperature, and at a depth of about 80 m.

Germon or the albacore seems to have been caught in our waters since the beginning of the nineteenth century, as its name is first found in the literature of a very early period of that century. In former days the germon was caught unintentionally, while engaged in fishing for the common tunny or other kinds of fish, and was not valued, as its flesh is soft, but recently a special long-line has been used for its capture. Caught chiefly by means of long lines and drift-nets.

Flesh pinkish in colour, soft, and not good for "sashimi", hence not much esteemed in our country, but the amount of flesh is comparatively large. The canned flesh is much esteemed as "tuna" in the United States of America.

Germon feeds on pelagic plankton, crustaceans, and small fish. I found a young germon about 30 cm in length in the stomach of a large germon, caught on January 20th, 1917 near the Ogasawara Islands, and other small ones from a yellow finned tunny and a spear-fish, caught on February 27th of the same year. Such small individuals are not caught nor found near the coast of the main island.

I cannot tell at present whether the germon of the Atlantic and the Mediterranean is the same as the Pacific germon. Specimens of the germon and the common tunny of the Mediterranean were sent to me from the Zoological Station at Naples in 1914 on a German steamer; but unfortunately the steamer was seized in the Red Sea and these specimens did not reach me. Many authors seem to have confounded this species with other species of tunnies with long pectorals.

Thunnus orientalis (Schlegel).

Kuroshibi, gotohshibi, maguro, medi (immature).

Figs. 3, 21, 43, 44, 50.

Thynnus orientalis, Schlegel, Fauna Japon. Poiss. 94, 1802.
Orcynus schlegelii, Steindachner & Döderlein. Fisch. Japon. III, 11, Taf. 3, Fig. 1. 1885.
Orcynus thynnus, Kitahara. Journ. Fish. Bur. VI, 1, Pl. 1 Fig. 1, 1897.
Thunnus schlegeli, Fujita, Otaki & Higurashi, Fish. Japan, I. 21, Pl. 1905.
Thunnus orientalis, Kishinouye, Sui. Gak. Ho, I, 17, Pl. 1, Fig. 9, 1915.

D. 13–15, 14, 8–9. A. 13–15, 7–8. Gill-rakers 12–13 + 24–26. Scales 230.

Body plump, broad, and the caudal portion sharply tapering. Pectorals short, scarcely reaching the origin of the second dorsal, and tapering gradually towards the posterior end. The height of the second dorsal is longer than that of the first, nearly equal to that of the anal; but shorter than that of the pectorals. The lateral line has a sharp and peculiar bend over the pectorals, being bent suddenly upward and anteriorly above the origin of the fins, and then bent gradually downwards and backward again. SCHLEGEL writes that the eyes of this species seem to be larger than those of the common European tunny. In one year old fish, the eyes are larger, being contained ca 6 times in the length of the head, but in a fish of ca 2 metres they are contained more than 8 times.

The liver is nearly the same as that of the preceding species; but the margin is not much divided. Fine venules of the hepatic vein at the external surface, and big masses of vascular plexus at the internal surface are found.

Air-bladder is triangular, pointed at the posterior end. It is nearly straight, thick, and very wide at the anterior end, occupying the entire breadth of the abdominal cavity. Air-bladder of this species is however short, occupying a little more than half the length of the abdominal cavity. The external wall is uniformly thin. The inner wall is finely reticulated. At the middle of the roof of the air-bladder, there is a large round hole, which leads to an accessory conical sac, extending from the hole behind to the posterior end of the principal sac. At the anterior end of this upper accessory sac a vein is found to pour to from a segmentary vein. In immature tunnies the air-bladder is short, very narrow, and almost collapsed. The median part of the air-bladder is vaulted, and at the anterior end the cavity has two slight swellings.

Kidneys are short, and are restricted to the anterior part of the abdominal cavity. In immature forms they are ring-shaped, round the pharyngeal muscles, and terminate with a slender, short process just before the first haemal process. In adult forms, however, the posterior portion is not well developed. Ureters meet at the posterior end of the kidneys, or a little out of it. Near the level of the 7th or 8th vertebra, ureters approach each other towards the median line, and unite into a common canal.

Venules to the cutaneous vein are arranged in two rows, and those of the external side pass over the cutaneous artery, while those of the interior side run below the artery. These venules are formed from the union of many fine canals, forming the plexus round the dark red portion of the lateral muscle. Arterioles from the cutaneous artery are arranged in one row. Oesophageal artery is found but very short.

Skull broad, with convex lateral sides, and the broad and high parasphenoid. Basisphenoid thick. Alisphenoid extends downward at the median line. The anterior margin of the suboperclc is more or less concave. This is quite characteristic of this species.

The back is nearly black, especially at the anterior part of the body, but the colour gradually changes to greyish blue with metallic reflections in the posterior part. Belly greyish with many colourless transverse lines and rows of colourless dots in alternation. These lines and series of dots are twenty or more in number, and they are nearly vertical in young specimens, running through from the back to the belly; but they bend gradually backward towards the ventral median line as the fish grows. At first only colourless lines make their appearance, and afterwards series of dots are intercalated between them. Moreover the lines are also divided into dots afterwards at the belly, and they disappear gradually from the back. The dots are irregular in arrangement in the caudal region. First dorsal greyish, second dorsal greyish with yellow tip, dorsal finlets yellow, and the anal and anal finlets silvery. Pectorals nearly black, ventrals greyish. Iris golden yellow.

Flesh is dark reddish, comparatively firm, and not very oily. It is superior in quality, especially in colder months, and is much esteemed. Two year old fish are called " medi," and are much valued by epicurians. It is told that in and after the spawning season the flesh is often mottled with darker spots and is much inferior in quality. Such flesh is distinguished by the name of " azukimi ", meaning red bean flesh.

This species attains a gigantic size. Mr. HIDEO SUZUKI told me that two large tunnies, each weighing about 375 kg were caught in a pound-net near Odawara in 1913. These were exceptionally large. Tunnies weighing more than 150 kg are considered pretty large in general.

This is the most common species of our tunnies, widely and abundantly distributed in our waters. It is easily distinguished from other tunnies by its small eyes, short pectorals, sharply bent lateral line, triangular air-bladder, finely striated liver, white markings in the belly, yellowish finlets without black margin, etc.

In winter this species is found in the southern part of our coast, as far south as 32° N. Not found near the Ryukyu Islands, Taiwan, nor Ogasawara Islands. In summer this tunny migrates northward as far as about 46° N. In winter the tunny fishing is actively pursued on the Pacific coasts of south and middle Japan, by means of long lines on or round deep, off-shore banks, and on the northeastern coast of Hondo by means of drift nets. In summer this tunny is caught on the Pacific coast as well as on the Japan Sea coasts of north Japan by means of pound-nets. Only a few examples are caught on the east coast of Chosen. Found in waters of 5–20° C, and most abundant in waters of 10–15° C. Thus the optimum temperature for this species is lower than that of the other tunnies in our waters, as well as that of the common Atlantic tunny.

When albacores or spear-fishes begin to be caught, this tunny's season is nearly over. It feeds on different kinds of fish, more or less pelagic in habit, such as sardine, anchovy, flying fish, scad, sand-eel, etc.; but sometimes fishes living near the bottom are found in the stomach. Calamaries and pteropods; *Pyrosoma*; pelagic crustaceans, such as *Euphausia*, *Sergestes*, *Acanthephyra*, larvae of Brachyura and Stomatopoda, anomalous Amphipoda, etc. are also found in the stomach.

This species is closely allied to the blue-finned tuna or leaping tuna of the Californian coast, but differs from it in the colour of fins, and in the mode of ramification of canals of the cutaneous blood-vessels. A similar or the same species is said to inhabit the Hawaiian waters; but I have not yet had a chance to investigate this.

Tunnies are migratory, but they resort and seem to stay for a while at the top of deep banks, often 200 m deep. In the vicinity of such banks tunnies seem to find plenty of food. The presence of tunnies in deep water is often detected by fishermen from the behavior of sea-gulls, flying fast in a much dispersed wide circle, or from circular or oblong waveless spots, ca. 1 m in diameter, produced for a time at the surface of the sea. These spots are called "nagi", meaning calm, waveless, and are believed by fishermen to come from the oil of fish devoured by tunnies; but as tunnies mostly engulf their prey in toto, and moreover as I did not observe any glittering iridescence in these spots, the explanation is not satisfactory.

Tunnies are devoured by killer-whales which are said to catch them at the nape and kill them immediately, so that they fear killers so greatly that they are frightened away several miles from the spot where these ferocious enemies are found. Thus catches made by pound-nets vary greatly according to the favourable or unfavourable proximity of killers. Sometimes tunnies leap on beaches recklessly to escape from these enemies.

In their northerly migration tunnies swim quite near the coast, and are caught in pound-nets, which are set in a depth of about twenty metres.

Small fish of about 25 cm, weighing ca. 20 g in weight are caught with rod and line late in summer. Such immature fish are called "imoshibi" in Miyazaki-ken. Still smaller fish are called "kakinotane" in Kanagawa-ken, and "abuko" or "bintsu" in Miye-ken. These immature fishes are found in association with *Auxis*, feeding chiefly on pelagic crustaceans. These immature fish grow to a length of ca. 40 cm, weighing ca. 1 kg in winter, and in the next summer 2–3 kg in weight.

In summer, June and July, the reproductive glands are very large, and the fish swarm near the surface of the water, often showing their dorsal fins out of water. This is the case in the northern parts of our waters, both on the Pacific and Japan Sea coasts. These mature fishes are associated with immature fishes. I have, however, not yet examined a tunny with fully ripe reproductive elements, and in August the reproductive glands are found spent. So that we are inclined to believe that the tunny spawn in offshore waters. Off the southern part of Kyushyu and also off the Pacific coast of the central part of Hondo, we find small immature tunnies in summer and autumn. In these waters the common tunny with ripe reproductive glands is not known. But it is difficult to believe that those immature fishes migrated from the northern waters.

Tunnies are caught more on dark nights, and before a storm. When the weather is warm with a southerly wind, tunnies come near the surface of the water, and a good catch by drift-nets is expected. On a day of northerly wind drifters do not go out fishing. They are said to swim against the current, especially when they are near the coast, hence they enter bays or inlets in low tide and seek off-shore grounds in high tide. Tunnies dislike a water of a low density, so that they do not approach the coast on a rainy day, nor approach the mouth of a river. They are found in a water of ca. 1.024–1.025 in density.

It is said that when a shoal of tunnies is frightened at something ahead of them, every tunny of the shoal turns back immediately just at the spot where it happens to be. Thus the hindermost fish lead the school when retiring. In 1921 a few immature tunnies were caught off Sendai in set-nets, at a depth of ca. 300 m. The nets were for a kind of deep-sea sharks. These tunnies were probably entangled, while the net was being hauled in, or when letting it out in the sea.

This species seems to descend to a depth of about forty metres below the surface of the water.

Genus **Parathunnus** gen. nov.

Cutaneous blood-vessels are found from the myotome of the seventh vertebra backward. The posterior cardinal vein does not communicate with the Cuvierian duct directly. At the margin of the exterior surface of the liver a few short venules are found. On the internal surface of the liver, conical masses of plexus of venules only are found, arteries not being divided in the masses. The right side of the stomach receives an artery from the right dorsal branch of the coeliaco-mesenteric artery.

Parathunnus mebachi (Kishinouye).

Mebachi, darumashibi, hirashibi, mebuto.

Figs. 4, 22, 47, 49.

Orcynus sibi, Kitahara, Journ. Fish. Bur. VI, 1, Pl. 1, Fig. 2, 1897.
Thunnus mebachi Kishinouye, Sui. Gak. Ho, I, 19, Pl. 1, Fig. 11, 1915.

D. 14–15, 13, 9. A. 13, 9. Gill-rakers 8–10 + 18. Scales ca. 190.

Body very broad, the caudal portion short, and the head and eyes large. The dorsal outline of the body is much curved; but the ventral outline is much more curved. Scales in the corselet very large. Length of the head nearly equal to the height of the body in young specimens, but it becomes a little shorter in old individuals. The anus is nearly in the middle between the snout and the end of the caudal fin. Scales large ca. 190 in the lateral line, which has a gentle, wavelike elevation above the pectorals. Pectorals are long, gradually pointing towards the distal end. In large specimens they scarcely pass beyond the origin of the second dorsal, but in small specimens ca. 1 m in length, they reach the first dorsal finlet, and the vertical passing through the middle of the anal. Second dorsal and anal are only a little higher than the first dorsal, and they are comparatively narrow and falciform. The caudal fin is widely expanded, wider than the height of the body. Posterior portion of the first dorsal has the convex outline generally.

Air-bladder well developed. It is divided into two heads at the anterior end, which lie on both sides of the dorsal aorta and between the pharyngeal muscles and cutaneous arteries. Kidneys are prolonged posteriorly to the segment of the thirteenth vertebra. Ureters of both sides run side by side in the narrow portion of the kidneys, and become confluent just at the posterior end of them.

Venules to the cutaneous vein are arranged in two alternate rows. Those of the exterior side pass over the cutaneous artery after joining many minute canals in the chiai plexus, and those of the inferior side unite to the cutaneous vein, just after joining minute canals. Arterioles from the cutaneous artery are arranged in two rows, one row on the remotest side from the accompanying cutaneous vein, the other on the nearest side to the vein. Arterioles in the former row are nearly twice more numerous, but smaller than those in the latter row. Thus two sheets of vascular plexus are formed from groups of the two rows of both arterioles and venules. Cutaneous arteries are sent from the dorsal aorta just below the eighth vertebra. The posterior cardinal vein is insignificant. Segmental veins in the precaudal region and in some anterior caudal segments running towards the vertebral column are divided up into minute vessels there. Venous blood from these vessels seen to be taken up by capillaries of the dark red portion of the lateral muscle.

Intestine longer than in the other Japanese tunnies, the third bend of it reaches nearly the first. Three lobes of the liver are thick, and triangular. Only a few, short, sparingly branched venules on the external surface of the middle and left lobes. Bulbous masses of vascular plexus are found on the inner side of the liver. These masses are slender and elongated, as the arteries in them take no part in the formation of the plexus, but run through them nearly straight.

Preopercle higher than broad, and the interopercle is nearly as high as broad. Haemal spines in the precaudal region are rather long. Parapophyses well developed, long, flattened at the distal end. They are directed downward from the ninth vertebra, and form the haemal arch from the tenth vertebra. Caudal vertebrae not so well developed as in other tunnies.

Back nearly black to greyish blue, sides silvery, and the iris silvery with bluish tint. Dorsal fins greyish, tinged yellow at the margin or the tip, finlets yellow. Pectorals are black at the dorsal side, but greyish at the ventral side, and the tip is sometimes washed with yellow. Ventrals are greyish and tinged with yellow, while the anal is white with the yellow tip. Anal finlets are greyish with yellowish margin. In young specimens under 7.5 kg in weight, the sides are greyish with a few colourless lines and series of colourless dots, running transversely.

The flesh is pinkish in colour, rather soft, especially in young individuals. Thus this species is considered a little inferior to the common tunny.

Very voracious fish, feeding on sauries, bonitos, luminous fishes, such as *Maurolicus*, and allied kinds, cuttle-fish, and Amphipoda, *Sergestes*, *Acanthephyra*, etc.

This species lives in a deep layer of water, ca. 20–120 m below the surface, 13–25° C in temperature, in offshore waters. Northern limit of distribution is ca. 36° N. Caught at the southern coast of our country and also at the Ogasawara Islands, Ryukyu Islands, and Taiwan. Not yet known from the Japan Sea. In 1920 I observed a similar or the same species at the market of San Pedro, but as I did not examine the anatomy in detail, I can not tell exactly to which species it belongs. The broad body, the form of the liver, hepatic venules, etc. were nearly the same as the Japanese species. Japanese fishermen say that this species occurs in Hawaiian waters too. Probably widely distributed in the deeper layer of the subtropical region of the Pacific Ocean.

At night the fish seems to come near the surface, as do other species of tunnies, and on moon-light nights catches are generally good.

The fish grows to a total length of ca 2 m with a weight of ca 86 kg. Fish of ca 70 cm is the smallest fish caught. I found skeletons of small examples, ca 30 cm in length in the stomach of a *Neothunnus macropterus*, caught near the Ogasawara Islands in January 1919.

Hirokata Yashiro (78) is probably the first author who has written about this species, distinguishing it from the other species by the larger eyes. Well known authors after him mention this species in their list of fishes. Thus this species seems to have been caught in our country from about the beginning of the nineteenth century.

Though this species has many distinctive characters, it is rather difficult to identify it, especially when there is no other species to compare with. Sometimes we receive reports that this species has been caught in pound-nets; but we are inclined to doubt the accuracy of the reports, as it is, so far as we know, pelagic and does not approach the coast.

KITAHARA (48) identified this species with *Thynnus sibi* of SCHLEGEL (67), but the latter author writes that the species is very common, during summer months, and is caught in hundreds at a time by means of nets of large dimension. This statement is not adequate for the present species. Moreover there are no decisive characters in the description by SCHLEGEL, except the long pectorals and remarkable height of the body. Probably SCHLEGEL confounded this species with *Neothunnus macropterus*. CUNNINGHAM (10) considers this species to be identical with *Thynnus obesus* LOWE of the Atlantic; but our species differs from the latter in the colour of the second dorsal, and the anal at least. According to CUNNINGHAM these fins have "some black at edges, but little or no yellow." The descriptions of *Thynnus obesus* by LOWE (52) as well as CUNNINGHAM are very incomplete. It is allied to the present species in having large eyes, and a short, thickset figure. But as the other important structures of *Thynnus obesus* LOWE are unknown, it is impossible to ascertain the relation between these two species.

Recently the catch of this species is said to have much increased, due to the use of long snoods among snoods of normal length on a long line. The lower end of these long snoods will hang in a layer of water, deeper than 57 m under the surface of the sea. At present this species is very common in the grounds near the mouth of Tokyo Bay.

Genus **Neothunnus** gen. nov.

Cutaneous blood-vessels are found from the segment of the seventh vertebra. Posterior cardinal vein is united to the right Cuvierian duct, and the former vein is connected with a plexus of blood-vessels in the haemal canal, so that the haemal arch is remarkably wide. The first haemal arch is found in the 11th vertebra. On the exterior surface of the liver we find no minute veins. Caudal vertebrae elongated, and accordingly the caudal portion long.

Key to the the Japanese species of the genus *Neothunnus*.

Air-bladder present, second dorsal and anal much elongated.................*N. macropterus*.
Air-bladder absent, second dorsal and anal slightly higher than the first dorsal..*N. rarus*.

Neothunnus macropterus (Schlegel).

Kihata or kiwada, gesunaga, hashibi, hatsu, hirenaga, itoshibi, kinhire, kimedi (immature).

Figs. 13, 19, 23, 45, 51.

Thynnus macropterus, Schlegel, Fauna Japon. Poiss. 98, Tab. 51; Day, Fish. India, 253, 1892.
Orcynus macropterus, Kitahara, Journ. Fish. Bur. VI, 2, Pl. 2, Fig. 3, 1897.
Germo macropterus, Jordan & Seale, Bull. Bur. Fish. XXV, 228, 1906.
Thunnus macropterus. Kishinouye, Sui. Gak. Ho, I, 19, Pl. 1, Fig. 12, 1915.

D. 13, 14, 9. A. 14–15, 8–9. Gill-rakers 9+21. Scales ca. 270.

Body fusiform, elongated, head small, and the caudal portion long. Scales minute. Pectorals long, pass beyond the origin of the second dorsal, their dorsal and ventral outlines are nearly parallel to each other, and are connected by a short oblique side near the distal end. The second dorsal and the anal are much elongated, especially in a variety named itoshibi or gesunaga, the tips of these fins are whitish and reach to the base of the caudal. So far as I have examined there is no marked difference in anatomical structure between the long finned variety and the ordinary form, except in the length of the second dorsal and anal fins.

No venules on the surface of the liver, the left lobe of which is sometimes divided into two, and the right lobe is longer than the other. Pyloric coeca as a mass is shorter than the stomach. Intestine rather short, the third bend scarcely reaching the middle between the first and the second. The rectum is also short. Air-bladder narrow and long not divided at the anterior end. Thick strong connective tissue protects the ventral part of the air-bladder.

Venules to the cutaneous vein are arranged in one row on the side towards the lateral median line. These venules run over the external side of the cutaneous artery, after uniting many fine venules. Arterioles from the cutaneous artery are arranged in one or two alternate rows from the side near the lateral median line. Cutaneous blood-vessels are found at the surface of the lateral muscle behind the origin of the first dorsal. A cutaneous vein on each side of the body pours separately to the Cuvierian duct of the respective side, or is united to the cardinal vein below the ninth vertebra, and in the kidneys. The cardinal vein joins the right Cuvierian duct. In the haemal canal the cardinal vein is united with a plexus of short transverse venules forming a dark red rod of plexus with similar arterioles from the dorsal aorta. It is remarkable that this rod of vascular plexus is found in the tunnies which want the conical vascular plexus on the inner side of the liver.

Kidneys are much elongated posteriorly, reaching to the segment of about the fifteenth vertebra. Ureters are united forming an acute angle under the thirteenth vertebra, and the common ureter is found behind the vertebra. Thus the ureters are shaped like the letter Y.

Vertebral column rather slender, and the second vertebra is nearly as high as broad. The posterior caudal vertebrae are remarkably elongated. Parapophyses long and flattened. They become more or less vertical in the eighth vertebra, turned downwards in the ninth vertebra, and an arch from the eleventh vertebra. Haemal canal wide, especially in the precaudal region, where the breadth of the cavity is nearly equal to that of the middle part of the respective vertebra. In one specimen I found the dorsal and ventral spines of the 36th vertebra short and nearly horizontal, instead of long and covering those of the next vertebra.

The colour is nearly black at the back, sides greyish with oblique transverse lines and series of dots of silvery white in alternation. Iris greenish yellow; first dorsal greyish tinged with yellow; tips of the second dorsal and dorsal finlets bright yellow; pectorals black on the inner side, greyish or sometimes yellowing on the outerside; ventrals greyish, tinged with yellow; anal and anal finlets bright yellow.

Distribution very wide, found in the Indo-Pacific region. Prefers warm water, 15–25° C mostly in the water of ca. 20° C. Northern limit of the distribution is ca. 35° N, but sometimes found beyond 40° N. Occasionally found in the Japan Sea, and is caught in Hokkaido, near Otaru, late in summer. Found in the Hawaiian waters and south Californian coast.

Large specimens measure more than 7 m in length, and ca 200 kg in weight, next in size to our common tunny.

They swim near the surface of the sea, especially in summer, and closely approach the land; but small immature fishes ca. 2 kg in weight are always in the off-shore grounds, accompanying a school of the striped bonitos. Larger ones are caught by troll-lines, long lines, drift-nets, circle nets, pound-nets, set nets, etc. Smaller ones are caught with rods and lines, circle nets, more than 7 m in lengsh, and ca 200 kg in weight, nex in size to our common tunny, etc. The variety called gesunaga is said to be shyer than the ordinary form, not easily biting hooks, though it swims very near by and often touches them. The longer-finned variety is said to be plentiful in autumn.

The flesh is beautifully pinkish, firm, and its taste is excellent. Mostly consumed fresh, being much esteemed for "sashimi". Many immature fishes are used for making "fushi" by smoking and drying after boiling in water.

They feed on flying fish, coffer-fish, some deep-sea fish, calamaries, pteropods, heteropods, Hyperina amphipods, *Squilla*'s larvae, and immature *Squilla*, megalopas of crabs, etc.

The spawning season of *Neothunnus macropterus* is not yet known. Some specimens examined in autumn at Kyushyu are said to have contained large ovaries.

This species is allied to *Thynnus albacora* LOWE, so far as its external characters are concerned, so that GÜNTHER and CUNNINGHAM consider the former to be identical with the latter; but as in the case of the other exotic species the anatomy of *Thunnus albacora* has been little studied, therefore it is impossible to determine the question.

Neothunnus rarus (Kishinouye).

Koshinaga, bintsuke, hashibi, seiyoshibi, shiroshibi, tongari.

Figs. 24, 48, 64.

Thunnus rarus, Kishinouye, Sui. Gak. Ho, I, 23, Pl. 1, Fig. 13, 1915.

D. 13, 14, 9. A. 14, 8. Gill-rakers 5-6 + 15-17. Scales ca. 220.

Body broad, head and eyes comparatively small, snout short, and caudal portion elongated. Scales minute. Curve of the lateral line above the pectoral very gentle. The number of gill-rakers is minimum in our Plecostean fishes. Pectorals broad, lanceolate, scarcely reaching to the vertical from the last but one spine of the first dorsal. Second dorsal and the anal are a little higher than the first dorsal.

Right lobe of the liver longest. Air-bladder absent. This is the only kind of the Japanese tunnies, which lacks it. The posterior end of the kidneys is very narrow and extends nearly to the segment of the fifteenth vertebra. Ureters are united to a common duct under the 12th vertebra.

Venules to the cutaneous vein are arranged in one row, on the side towards the lateral median line. These venules run side by side with the arterioles, and are united to a large vessel just before joining the cutaneous vein. The upper half of the diameter of the cutaneous artery is concealed under the cutaneous vein, and arterioles from the cutaneous artery are arranged in one or two rows, and more numerous than the venules, are sent from the exterior median line of the cutaneous artery. A cutaneous vein on each side of the body joins the cardinal vein below the ninth vertebra, and the cardinal vein pours into the right Cuvierian duct. Each cutaneous vein sends a large branch to the kidneys, before joining the cardinal vein. This is a renal portal vein.' In the haemal canal a thick rod of plexus of transverse arterioles and venules is joined. The diameter of the plexus is a little broader than that of the vertebra in the precaudal region. The second branch of the coeliacomesenteric artery nourishes the right dorsal side of the stomach, spleen, and intestine.

Second vertebra wider than high. Transverse processes are not well developed and are turned downwards from the ninth vertebra, and the haemal arch is closed from the 11th vertebra, as in *Neothunnus macropterus.*

Back greyish blue, sides silvery greyish with colourless elongated spots in about five longitudinal rows. Dorsals, pectorals, and the ventrals blackish, but the tip of the second dorsal and the anal is washed with yellow. Anal fin silvery. Finlets, both dorsal and anal are yellowish with greyish margin.

Smallest tunny not only in our waters, but perhaps in the world. Fish about 70 cm in length and ca 6 kg in weight is common. Such a small tunny contained large and nearly ripe ovaries in February. Fish-mongers told me that a 12 kg fish is maximum.

Flesh is pale in colour, fatty and rather soft, but its taste is very nice.

Very limited in distribution. Found on the western and southern coast of Kyushyu and on the southwestern part of the Japan Sea. So far as I know, it is caught very near the coast, rather rare, and was quite unknown to science, till I got it from the market of Tokyo in 1913. People of the market considered it as a variety of *Neothunnus macropterus.* It is rather striking that this species remained unnoticed for a very long period. In autumn a few examples are said to be found every day in the market at Nagasaki.

Caught in pound-nets, and sometimes with rods and lines in littoral water in association with small bonitos.

This species feeds, so far as I know, on small fishes only;—one specimen contained two mackerels in its stomach, the second specimen fourteen examples of *Stolephorus glacilis*, and the third three half-beaks and some anchovies.

On December 17th, 1918, one of this species was found dead on the beach near the mouth of Gōnokawa, the largest river in Shimane-ken, probably scared by killer-whales or some other ferocious enemies.

Family KATSUWONIDAE Kishinouye.

Katsuwonidae, Kishinouye, 1917.

Body plump, rounded in cross-section, and naked outside of the corselet. Lateral line without a marked undulation above the pectoral fin. First dorsal very high at the anterior end, becoming suddenly low behind. Second dorsal remarkably lower than the first dorsal, and the anal and second dorsal are smaller than the ventrals. Pectorals very short and triangular. In this family the haemal canal is closed behind the middle of the precaudal region. Dentition weak, generally only one row of small teeth in both jaws. When teeth are found in other bones, they are arranged in one row only, never more. On the roof of the mouth-cavity no dentigerous calcareous plates. Tongue smooth with a ridge on each lateral side. No air-bladder. Pyloric coeca minute, numerous, uniform in size, and developed on the terminal branches of pyloric tubes, arranged on both sides of the duodenum. The loose and thick membrane surrounding the stomach in the Thunnidae is not found in this family. Three lobes of the liver unequal, and generally the right lobe is much elongated, except in the genus *Katsuwonus*. Intestine very short, without a loop. Rectum is nearly the same in length or a little longer than the remaining part of the intestine. The longitudinal folds of the internal layer of the duodenum extend to the straight small intestine, just to the beginning of the rectum.

The circulatory system which is related to the formation of the dark red portion of the lateral muscle, differ more or less from that of the Thunnidae. In the present family the cutaneous blood-vessels are also two in number, on each side of the lateral median line; but the hypaxial vein is divided to renal portals, and the hypaxial artery passes through the kidneys, taking a slight downward course, and runs backward anterior to and above the series of the ribs. Except in the case of the genus *Katsuwonus*, the hypaxial blood-vessels are much smaller and shorter than the epaxial, and the plexus of blood vessels surrounding the dark red portion of the lateral muscle are united to the epaxial blood vessels only. Indeed the epaxial blood vessels of the Katsuwonidae seem to correspond to the entire cutaneous system of the Thunnidae, and the hypaxial vessels of the former seem to be sui generis. The posterior cardinal vein joins the right Cuvierian duct, and joining this cardinal vein is a small renal vein. The interhaemal rod of the vascular plexus attains the utmost development in *Katsuwonus* and *Euthynnus*. The rod is thicker than the diameter of the vertebral column, and is protected by the bony trellis formed by haemal processes of the column, from the enormous development of the inferior foramen. In the genus *Auxis*, however, the interhaemal rod of the vascular plexus is very thin, and the inferior foramen is formed in a few caudal vertebrae only, having no relation with the vascualr plexus.

Kidneys much elongated. Ureters are nearly separate, running almost parallel to each other in the posterior slender portion of the kidneys. The spleen is smaller than that of tunnies and is situated at the anterior portion of the visceral cavity.

In the hypaxal dark red portion of the lateral muscle, just below the series of intermuscular bones a large strong tendon from the second vertebra is sheathed with thin layers of some muscle segments, from the myotomes of the third and some succeeding vertebrae. Thus in each epaxial portion of the lateral muscle two concentric rings of muscle segments are found in the cross-section. This is quite characteristic of the Katsuwonidae. The axial side of the lateral muscle meets the axial skeleton in the epaxial as well as the hypaxial portion, and the dark red portion is more voluminous than in the Thunnidae.

The vertebral column is very firm, light, and compact, allowing no lateral motion. In anterior precaudal vertebrae the neural canal is separated from the canal of the spinal ligament by a thin bony septum as in the Scombridae. Neural process of the first vertebra is more or less united to the centrum and the posterior dorsal zygapophyses are very well developed in the vertebra. Parapophyses are quite abortive.

Dentigerous ossicles on the gill-arches are large and are arranged in one row only. Internal gill-rakers are well developed.

Long intermuscular bones on anterior precaudal vertebrae, which have their distal end at the surface of the body are found as far as the seventh vertebra. From the eighth vertebra backward some long intermuscular bones are also found, but they are not ossified in the middle portion. Intermuscular bones are well developed and are found on every vertebra, except those which have the lateral keel, and behind the attachment of intermuscular bone there is a pointed tubercle in the vertebra.

External and internal portions of the clavicle are perpendicular to each other.

Below each eye an oval black spot is generally found. This colour spot is distinct, especially in the genus *Auxis*.

Fishes of this family feed chiefly on small fishes and medium sized plankton. They are liable to perish sooner than those of the Thunnidae.

Key to the genera of the Katsuwonidae.

The first dorsal is continuous to the second, a pair of foramen on the dorsal surface of the skull, inferior foramen of vertebrae well developed, thus the so-called trellis is formed.
- Both epaxial and hypaxial blood-vessels under the skin are equally well developed, teeth in both jaws only, vertebrae 20-21.......... *Katsuwonus*.
- Hypaxial blood-vessels under the skin are atrophied; epaxial blood-vessels run just above the lateral median line of the body, teeth in both jaws, palatines, and sometimes on the vomer too, epihaemal spines well developed, vertebrae 20-19. .... *Euthynnus*.

The first dorsal is not continuous with the second; no foramen on the dorsal surface of the skull; hypaxial bloodvessels under the skin are atrophied; teeth in jaws only; inferior foramen scarcely developed; epihaemal spines well developed, long; vertebrae 20-19.......... .... *Auxis*.

Genus **Katsuwonus** Kishinouye.

Katsuwonus, Kishinouye, Sui. Gak. Ho, I, 21, 1915.

Body plump, rounded in cross-section, and we find a few minute scales scattered in the thick skin, outside of the corselet. Teeth in jaws only, about forty in each. Gall-bladder long, nearly free from the liver, and runs along the dorsal side of the intestine.

The cutaneous circulatory system is unique. A pair of cutaneous arteries branch just behind the insertion of the pharyngeal muscles as in the tunnies and other bonitos; but passing through the kidneys the arteries turn outward and forward, instead of turning more or less backward as in the other plecostean fishes. Each artery reaching to the myotome of the first rib is divided into two arteries, epaxial and hypaxial. The epaxial artery runs below the first rib, while the hypaxial artery runs above the rib. These two arteries, are nearly equally developed, and are separated from each other at a distance of 6-8 times the breadth of the blood-vessels. These arteries do not form a loop at the caudal region. The cutaneous artery and cutaneous vein lie in juxtaposition, nearly flat at the surface of the body. Arterioles and venules connected with these cutaneous canals run in opposite directions, along the surface of the body, and they are not so numerous as in the tunnies. The rod of the vascular plexus in the haemal canal is called kurochiai by fishermen, and it is thicker than the diameter of the vertebral column.

This genus is closely allied to the genus *Neothunnus* of the Thunnidae and stands quite near the genus *Euthynnus*. Number of the precaudal vertebrae corresponds to that of *Euthynnus*, while the number of caudal vertebrae is equal to that of the Thunnidae. Thus the total number of vertebrae is 41, while in all the other genera of the plecostean fishes the number is always 39.

Only one cosmopolitan species is known from the temperate and tropical regions of the world.

Katsuwonus pelamis (Linnaeus).

Katsuwo, magatsuwo, mandaragatsuwo.

Figs. 5, 14, 19, 25, 52, 57.

Scomber pelamis, Linnaeus, Syst. Nat. X, 297, 1758.

Thynnus pelamys, Cuv. & Val., Hist. Nat. Poiss. VIII, 113, Tab. 214, 1831; Schlegel, Fauna Japon. Poiss, 96, Tab. 49, 1850; Günther, Cat. Brit. Mus. II, 334, 1860.

Gymnosarda pelamis, Dressler & Fesler, Bull. U. S. Fish Comm. VII, 436, 1889, Jordan & Evermann, Fish. N. & M. America, I, 868, 1896.

Euthynnus pelamis, Tanaka, Fish. Japan, I—X, 140, Pls. 37, 39, 40, 1912.

Katsuwonus pelamys, Kishinouye, Sui. Gak. Ho, I, 21, Pl. 1, Fig. 14, 1915.

D. 12-17, 11-14, 8. A. 11-15, 7. Gill-rakers 15-20+36-39.

Body plump, sharply pointed at both ends. Lateral line slightly curved upward above the pectorals and bent below the second dorsal, and nearly horizontal in the caudal portion. Gill-rakers numerous, very thin, and their inner margin undulating. The right lobe of the liver is small and slender.

Plexus of venules from the posterior cardinal vein forms a long continuous mass like a rod with the plexus of arterioles from the dorsal aorta to the vertical of the ninth vertebra; but anterior to the vertebra the plexus is discontinued and is divided only into small bundles of venules.

Kidneys are much elongated posteriorly. In the haemal canal, below the vertebral column, there is also a renal body.

The back is dark bluish violet, with some transverse light coloured markings, the sides are silvery with four or more dark coloured longitudinal bands on each side. Dorsals, dorsal finlets, pectorals, and the anal are dusky. Iris silvery, with a greenish shade.

The bonito lives in the clear blue water of the Kuroshiwo, 20–30° in temperature, and 1.024–1.026 in specific gravity. On the Japan Sea, this fish is caught in small numbers, late in autumn or in winter only, there being no special fishing for this fish. On the northeastern coast of Hondo, the bonito is generally caught in grounds very far from the land, 100–200 miles off. In spring bonitos begin to migrate northward, and reach the ground off the southeastern coast of Hokkaido in summer. Sometimes the fish makes big shoals of several hundreds to thousands, and when they attack a school of small fishes, such as sardines and anchovies, they surround the latter till the victims form a dense spherical mass. Then the bonitos feed gradually on the stragglers from the school, swimming around outside the mass. Generally they feed on the medium sized plankton:—amphipods, *Squilla*'s larvae and other crustaceans, pteropods, heteropods (chiefly *Atlanta*), calamaries, and immature or small fishes, etc. According to experienced fishermen, bonitos are said to contain plenty of food in their stomach, when they are caught in large quantities with rods and lines; but almost no trace of food is found in their stomachs, when refuse to bite a hook. This is true also of the tunny fishery by means of long lines. Though bonitos and tunnies are very voracious and bite a hook easily and eagerly, especially when they are in a frenzy of competition to get as much food as possible, yet they are cool and cautious when there is only a little food. And in midsummer when the reproductive elements become ripe, bonitos seem to fast. In the water round Ryukyu and the adjacent islands we find small bonitos about 20 cm in length in August, and in January I have obtained small bonitos ca. 30 cm (without caudal) from the stomach of tunnies, caught near the Ogasawara

Islands. These immature fishes are very slender, have faint longitudinal colour bands on the sides and the sooty belly. These fishes are most probably yearlings, hatched late in spring of the preceding year.

Bonitos are sensitive fishes, being frightened away when the water is stained with blood, when a fellow fish is struggling furiously in a net, or when a fellow fish makes a narrow escape from a net or a hook. Therefore shark-fishing with a long line in the fishing ground of the bonito is considered in several districts to be harmful to bonito-fishing, as the death-combat of sharks is generally accompanied with blood-shed, which scares the bonito away. Long lines for the bonito are also believed to be injurious from a similar cause. Drift net fishing for bonitos and tunnies is also hated by the bonito-fishermen, as well as the circle-net fishing for these fishes. Bonitos are very active and powerful, but they are not tenacious of life and can not withstand unfavourable conditions long. Thus when caught in a drift net or a drift long line they very soon succumb. In this point bonitos seem to differ very much from tunnies.

Bonitos are very good swimmers, their velocity being roughly estimated to be more than 25 miles an hour. They migrate in shoals in search of food, and do not stop at any particular spot for a long time, though they often remain for a while round shallow banks in a warm clear water, as several kinds of small fishes are always found in such places.

Bonito-fishing is carried on at the Pacific coast of our empire, in Hokkaido in the north, as an important industry. On the west coast of Kyushyu and in the waters round the Ryukyu Islands and Taiwan this fishery also thrives. Bonitos are chiefly caught with rods and lines, alluring a shoal of fish with live baits thrown from the boat, as the net-fishing is not suitable, owing to the clearness of the water. Long lines are sometimes used. The snood is 3–4 m in length and the distance between two consecutive snoods is about 8 m. These lines are slender and not very strong.

Bones of this fish are found in the remains of shell-mounds in the north-eastern part of Hondo. In the "Yengishiki," a classical work on ceremonies in the imperial court, etc., compiled in 927, many kinds of food prepared from the bonito are enumerated, and these articles were given as tribute to the government and the imperial court. In an article in "Tsurezuregusa," a well-known literary work by KENKO YOSHIDA at the time of the Ashikaga Shōguns, it is stated that the bonito was valued in Kamakura at that time, though it had been condemned as an inferior fish in previous times. In the time of the Tokugawa Shōguns, however, an extravagant price was paid for an early arrival of bonitos in late spring in Yedo, as was the case with the mackerel in London in former days. Many short poems called "hokku," mostly satirical, were written about the early bonito at the time, and many extraordinary tales are still told about it. At that time the fish was eaten raw as sashimi. Early in summer the generative organ of the bonito is still small, and the climate is not yet so hot as to cause quick putrefaction of the fish. Therefore bonitos of prime condition were obtained in this season, and at this time the fish was caught near the coast and was sent by express rowing boats, manned by about ten men to each boat. Thus the gastronomers of Yedo were able to taste bonitos in a prime condition, and to enjoy the very rich flavour a few hours after they were caught. At present bonito-fishing is conducted in very remote grounds only, and though caught in early spring, the fish are brought to market, preserved in ice, two or three days after capture. Consequently their choice flavour being lost, early bonitos are nowadays no longer estimated by epicurians.

It grows to a length of about one metre, generally 18 kg in weight, rarely 25 kg. Spawning seems to take place from May to August. Tunnies and spear-fishes are enemies. *Rhynchobothrium* is inevitably found in the flesh of the bonito, especially abundant in autumn. Bonitos caught in off-shore waters contain a much smaller quantity of fat than those caught in littoral waters. The flesh of bonitos is longitudinally cut into four pieces and then smoked and dried after boiling in water. This dried article called "katsuwobushi" is a necessary article in our household, being used as a condiment after shredding. Its annual production is ca 11,000,000 kg.

Genus **Euthynnus** Lütken.

Euthynnus, Lütken, MS. in Jordan & Gilbert, Syn. Fish. N. America, 429, 1883.

Body plump, rounded, and naked outside of the corselet. Mouth rather large, maxillary reaching the vertical from the centre of the eye. Teeth more developed in size and number than in the other genera of the Katsuwonidae.

They are found not only in both jaws, but also on the palatines and sometimes on the vomer too. Teeth on the palatines are in single row. The right lobe of the liver much elongated as in the genus *Auxis*. It is remarkable that the chief cutaneous artery runs along the dorsal external side of the chief cutaneous vein, quite contrary to the case in all the other forms of the plecostean fishes, and the dorsal segmental branches of the chief cutaneous vein pass over the accompanying artery, which is a little more or less deeply imbedded in the muscle. The degenerated hypaxial cutaneous artery lies ventral, that is external and similarly to the accompanying vein. Hypaxial, cutaneous blood-vessels are bent in a zigzag line. They have no connection with the vascular plexus, nourishing the dark red portion of the lateral muscle. The subspinal rod of the vascular plexus is also well developed, but the rod is separated from the vertebral column by the development of the epihaemal process, between the vertebral column and the haemal canal. Thus the inferior foramen is remarkably larger than in the genus *Katsuwonus*.

Dark markings in the naked part of the back, and generally some greyish spots in the pectoral region above the ventrals.

Fishes of this genus attain about the same size as the striped bonito. They are degenerated forms, derived from the genus *Katsuwonus*. Voracious fishes of temperate and tropical seas, not forming large schools, and often approaching the coast. Until recently only one species was known, but I have found other two species in the Pacific, quite different from the Atlantic species.

Key to the species of the genus *Euthynnus*.

Vomerine teeth present.
- Dark oblique bands on the back........ ....*E. yaito*.
- Dark longitudinal bands on the back. ....*E. lineatus*.

Vomerine teeth absent. ....*E. alleterata*.

Euthynnus yaito Kishinouye.

Yaito, hiragatsuwo, obosogatsuwo, segatsuwo, suma, uramawarigatsuwo, watanabe, yaitopara, yaitosuma.

Figs, 26, 54, 58.

Thynnus thunnina, Schlegel, Fauna Japon. Poiss. 95, Tab. 48. 1850.
? *Thynnus affinis*, Cantor, Cat. Malay. Fish. 106, 1850.

Euthynnus yaito, Kishinouye, Sui. Gak. Ho, I, 22, Pl. 1, Fig. 15, 1915.

D. 15–16, 12–13, 8. A. 13, 7. Gill-rakers 8–10+22–24.

Vomerine teeth present. This character clearly separates this species from the allied species of the Atlantic, with which it has been hitherto confounded, as the presence of the vomerine teeth in this species had been overlooked. Vomerine teeth are arranged in one row on a longitudinal ridge. Palatine teeth are also on one row only. The upper jaw has 27–30 teeth, while the lower has 24–27. Gill-rakers in this species are fewer in number than in the allied species of the Atlantic. The latter has 11–28.

The cutaneous artery sends arterioles from the inner and lower side in one row, while the venules to the cutaneous vein are arranged in two rows, alternate on the inner side. To the epaxial cutaneous blood vessels both the upper and lower segmentary branches are connected.

Skull broad, its breadth is contained $1\frac{1}{3}$ in its length. The alisphenoid and prootic meet, and form a bridge over the groove of the prootic. Two pairs of the auxiliary intermuscular bones are found on the dorsal surface of the exoccipitals, one pair of which is situated just above the foramen of the spinal cord, and the other at the lower end of paired vertical ridges continued from the top of the epiotic. The supraoccipital crest is very broad, and its vertical side meets the fused median ridge of the exoccipitals. In the specimen figured in fig. 58 the caudal vertebrae are very long.

Back bluish black with many dark oblique bands. Belly silvery with three or more greyish spots below the pectorals. Fins black or greyish, the ventrals are partly black and fringed with chalk-white. Iris silvery with beautiful reflection. A black spot under each eye.

Found chiefly in the southern part of our empire. The northern limit of distribution seems to be near Chiba-ken on the Pacific coast. Lately Mr. K. NOMURA sent me a specimen of this species, caught near Tsuruga, Fukui-ken in October, 1921. This is the first specimen from the Japan Sea. Among specimens of scombroid fishes from the Dutch Indies, kindly sent by Mr. GOBEE, I found three immature forms of this species, but the southern limit of distribution is not yet determined.

This species is rather rare, and is not found in schools. As it approaches the shore, a few examples are sometimes caught in drag seines and pound-nets.

Also caught with rods and lines associated with bonitos and immature tunnies.

Voracious fish, feeds on small fishes and medium sized plankton. When this fish encounters a school of small fishes, it darts into the crowd and scatters them in the same way as the pelamids and tunnies.

This fish attains a total length of ca 60 cm, and a weight of ca 3½ kg, but rarely a fish of one metre and more than 10 kg in weight is found.

Spawning seems to take place about in May in Taiwan. A young specimen measuring 11.5 cm in length was captured near the mouth of Keelung Harbour, on August 29, 1917. It is slenderer than the adult, and has about a dozen dark transverse bands, more or less oblique. These bands pass the lateral line downwards.

Flesh more or less firm and pretty good in taste.

Thynnus affinis of CANTOR seems to be identical with this species; but as he denies the presence of the vomerine teeth, it may be a different species. Moreover the colour of fins differs in *Thynnus affinis*. It is said that the second dorsal, anal, and their spurious fins are pale brownish yellow, edged and washed with black; while the caudal is yellowish buff, washed with brownish in the centre.

Euthynnus lineatus Kishinouye.

Euthynnus lineatus, Kishinouye, Sui. Gak. Ho. III, 113, 1920.

This species was created on a single specimen from Manzanillo, Mexico, collected by Mr. Naotaro Ota, in 1915. It differs from the other known

Fig. Z. *Euthynnus lineatus* 1/4.

species by the presence of about three longitudinal dark lines or rather bands in the naked portion above the lateral line. One row of teeth on the vomer and palatines as in *Euthynnus yaito*. In the new species the head is larger than in the other species. The specimen examined is 48 cm in the total length. In the thoracic part there are some spots or rather very short bands. Caudal portion very slender and short.

Genus **Auxis** Cuvier.

Auxis Cuvier, Regne Anim. II, 119, 1829.

Body rounded in cross-section, fusiform, and more elongated than in *Kasuwonus* and *Euthynnus*. Caudal portion remarkably short, while the precaudal portion is very long. Snout short, mouth small. Teeth in both jaws only. Fins small, especially the second dorsal, anal, and caudal. Posterior portion of the first dorsal has disappeared, and the fin is nearly triangular in shape, and is not continuous to the second dorsal. In the median prolongation of the corselet, we find no indentation at the ventral margin behind the pectorals. Lateral line slightly curved with small undulations. Tongue flat, smooth, and silvery.

Basioccipital together with the parasphenoid form paired horn-like processes behind to support the first vertebra above. Exoccipitals fused to one piece of bone, with a prominent dorsal median crest, just below the supraoccipital crest, thus affording a strong hold for the insertion of the lateral muscles. Deep transverse depression along the suture between the prootic and alisphenoid, corresponding to the ventral groove in the optic lobe of the brain. At the anterior border of the depression the alisphenoid is produced to a shelf to partly cover the depression. Pterotic process long and broad horizontally. The sphenotic does not appear in the dorsal side of the skull. Antero-superior corner of the subopercle produced. One pair of auxiliary intermuscular bones on the coalesced exoccipitals, just above the foramen for the spinal cord. Some intermuscular bones behind that of the 8th vertebra are divided into two portions and are connected by a ligament.

The first vertebra is not closely coalesced to the skull, and the upper posterior zygapophyses are long and large for the attachment of the clavicular ligament. The neural process of the first vertebra is weak and small. In the second vertebra the neural process and the lateral transverse processes are remarkably large. The former is for the attachment of the muscle of the first dorsal, and the latter for the attachment of a pair of strong tendons from the centre of paired small cones of myotomes. First three vertebrae have a pair of strong ridges or pillars at the ventral side respectively.

The centrum of the succeeding vertebrae is shaped like an hourglass, as longitudinal ridges are scarcely developed in them. Lateral keels are more or less developed in the majority of the caudal vertebrae, though many of them are not developed along the whole length of the side. In the precaudal vertebrae, ventral processes arise from the anterior end only, and they are united into a median rod, the epihaemal process of some length. At the distal end the rod is separated to parapophyses. The haemal arch and haemal spine are found in caudal vertebrae only. The epihaemal process is turned more or less forward in the caudal region as well, while the haemal processes are turned backward. Both neural and haemal processes from the vertebrae, with the exception of some caudal ones, are laterally compressed. Even in the first caudal vertebra, the epihaemal process is more or less turned forward and the process of that vertebra makes nearly a right angle with the haemal arch. The so-called trellis formed on the ventral side of the vertebral column is scarcely developed in this genus. Spurious interneurals are found between the two dorsals.

Epaxial cutaneous blood-vessels run near the lateral median line, and are united to segmental branches of both epaxial and hypaxial sides. These blood-vessels form sheets of the vascular plexus round the dark red portion of the lateral muscle, as the hypaxial cutaneous blood-vessels are atrophied as in the genus *Euthynnus*, and take no part in the formation of the plexus. The rod of the vascular plexus between the parapophyses in the precaudal region and in the haemal canal in the caudal region is thin and much degenerated.

The dark red portion of the lateral muscle the chiai is broadest near the vertebral column, as the chief axial blood-vessels are far removed from the latter. A comparatively large portion of the lateral muscle is coloured dark red. Besides a concentric sheath of muscles round the strong tendon from the second vertebra, there is another smaller concentric sheath of muscles round another tendon on the external side of the anterior part of the cutaneous blood vessels.

The dendritic course of the hepatic vein may distinctly be seen on the exterior side of the liver. The right lobe of the liver is exceedingly long, the other lobes are short and rather indistinct. The mass of the pyloric coeca is much shorter than the stomach. Kidneys are elongated. Two ureters are separated and open at the dorsal, anterior end of the bladder. Sexual gland when ripened develops backward along both sides of the thick row of interspinous bones of the anal fin. This is due to the narrowness of the abdominal cavity.

The back is dark greenish, it becomes dark bluish after death. Several oblique bands in the scaleless part above the lateral line. Belly silvery, with irridescent reflections. Oval dark spot below each eye.

Very widely distributed in the temperate and tropical waters. In warm seasons the fish approaches the shore, often in large schools, and is caught with seines, pound-nets, drift nets, rods and lines, etc. This fish is also found in the Japan Sea. It swims in the deeper strata of water in cold months, and disappears in winter from our coasts.

Very small in size, generally ca 30 cm in length.

The fish feeds on small plankton and small fishes, such as *Atherina*, *Stolephorus*, *Spratteloides*, immature forms of *Engraulis*, etc. It is inferior in taste, as it is coarse and moreover very perishable.

In our waters there are two different species of fish belonging to this genus. They resemble each other so closely that they have long been confounded by naturalists, and were considered to be the same species as the Atlantic congener.

Key to the Japanese species of the genus *Auxis*.

Body more or less compressed, only a few scales are found on both sides of the lateral line in the posterior part of the body; inferior foramen present in the last two vertebrae with the epihaemal spine (26th and 27th)......*A. hira*.

Body nearly rounded in cross-section, several rows of scales on both sides of the lateral line, no inferior foramen in the vertebrae with the epihaemal spine...*A. maru*.

Auxis hira Kishinouye.

Hiramedika, hiragatsuwo, hirasohda, obosogatsuwo, shibuwa, soma, suma, etc.

Figs. 55, 59.

Auxis hira, Kishinouye, Sui. Gak. Ho. I. 23, Pl. 1, Fig. 16. 1915.

D. 10–11, 12, 8. A. 13, 7. Gill-rakers 9+30.

Body more or less compressed, its height is nearly equal to the length of the head. Middle limb of the corselet ends a little behind the pectoral, and one or two rows of minute scales are found on either side of the lateral line.

The hypaxial dark red portion of the lateral muscle is larger than the epaxial. Myotomes of some body-segments seem to be subdivided in the dark red portion.

Long intermuscular bones, the tips of which are found to reach the surface of the body to the 11th vertebra, and the last four of them are not entirely ossified, leaving the middle part fibrous. The lateral process of the second vertebra is longer than the vertebra itself. The haemal arch of the first caudal vertebra is bent with a more or less obtuse angle. In the 23rd and some succeeding vertebrae there are paired downward processes from the end of the haemal process, and these processes nearly reach the origin of the haemal spine of the preceding vertebrae.

This species is very widely distributed. Its northern range reaches to Hokkaido and is known from the coasts of the Japan Sea, Korea, Ogasawara Islands, Ryukyu Islands, Formosa, etc. Caught in large numbers in southern regions.

This species grows to a weight of ca. 1.5 kg.

Seems to spawn in summer. Reproductive elements are nearly ripe in August.

This species is not so numerous as the other but the flesh being firmer is superior to the other in quality.

Auxis maru Kishinouye.

Marumedika, chiboh, dainanpo, magatsuwo, manba, mandara, marugatsuwo, nodoguro, rohsoku, subota, uzuwa, etc.

Figs. 2, 15, 27, 56, 60.

? *Auxis tapeinosoma*, Bleeker, Verh. Bat. Gen. XXVI, 98, Tab. 7, Fig. 1, 1854–57.
? *Scomber thazard*, Lacépède, Hist. Nat. Poiss. III, 9, 1802.
Auxis rochei, Kitahara, Journ. Fish. Bur. VI, 3, Pl. 4, Fig. 9, 1897.
Auxis maru, Kishinouye, Sui. Gak Ho, I, 24, Pl. 1, Fig. 19, 1915.

D. 9–10, 11–12, 8. A. 13, 7. Gill-rakers 10+36.

Body fusiform, nearly rounded in cross-section, and its height is smaller than the length of the head. The middle limb of the corselet is prolonged backward nearly the entire length of the lateral line.

The dark coloured portion of the lateral muscle is nearly equally large in the hypaxial and epaxial portions.

Depression along the suture between the prootic and the alisphenoid is sharply defined and narrow, and the shelf at the anterior border of the depression is obsolete. Only two intermuscular bones have the middle portion non-ossified. The lateral process of the second vertebra is short and thick. Neural process of some anterior vertebrae is not so broad as in the preceding species. The haemal arch of the first caudal vertebra makes a right angle with the epihaemal spine. From the lower end of the epihaemal spine a pair of short free processes is produced downward and forward in some caudal vertebrae. Free parapophyses from the lower end of the epihaemal process are short, and are but a little separated from each other.

This species seems to be more abundant than the preceding species. In distribution nearly the same as the latter. Known from South-Manchuria as well. Caught in pound-nets, set-nets, drift nets, rods and lines, etc.

Grows to a weight of ca. 640 g, the smallest species in the Plecostei.

Very poor food-fish, consumed fresh or salted.

Auxis tapeinosoma of BLEEKER seems at first sight to be identical with this species, but not exactly, as the dorsal finlets of the former are characterised as 9 in number.

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Explanation of Plates.

PLATE XIII.

Fig. 1. *Scomber japonicus.* Skin, hypaxial lateral muscle, and a part of the caudal portion removed, showing the vascular system, viscera, intermuscular tendons, etc.

Fig. 2. *Auxis maru.* Skin, pale coloured portion of the hypaxial lateral muscle removed, together with an external part of the dark red portion removed between the 13th to 18th vertebra. In the cross-sections of the lateral muscule, both epaxial and hypaxial of the dark red portion are represented. Two small cones of muscles round a respective tendon, axial and cutaneous (lower canal is not represented) vascular systems are shown.

PLATE XIV.

Fig. 3. *Thunnus orientalis.* Skin, anterior portion of the hypaxial lateral muscle, and a part of gills and gill-cover have been removed, exposing the cutaneous vascular system and the viscera.

Fig. 4. *Parathunnus mebachi.* Skin, hypaxial lateral muscle, most part of viscera, and the caudal peduncle removed, to show the vertebral vascular system, cutaneous vascular system, intermuscular tendons, etc.

PLATE XV.

Fig. 5. *Katsuwonus pelamis.* Skin, and hypaxial lateral muscle removed, to show the vertebral and the hypaxial cutaneous vascular system, viscera, etc.

Fig. 6. *Cybium niphonium.* Greater part of the muscle removed at the anterior part, leaving the intermuscular bones, the membrane connecting them, intermuscular tendons, median proximal portion of myocommata, and segmental blood vessels.

PLATE XVI.

Middle transverse section of vertebrae. The dotted line in the figures separates the caudal vertebrae from the precaudal, and the numeral in a smaller type is the number of a vertebra from the anterior end.

Fig. 7. *Scomber japonicus.*

Fig. 8. *Grammatorcynus bilineatus.*

Fig. 9. *Cybium niphonium.*

Fig. 10. *Acanthocybium solandri.*

Fig. 11. *Sarda orientalis.*

Fig. 12. *Gymnosarda nuda.*

Fig. 13. *Neothunnus macropterus.*

Fig. 14. *Katsuwonus pelamis.*

Fig. 15. *Auxis maru.*

PLATE XVII.

Cross-sections of the lateral muscles and the dorsal and ventral carinales (one half moiety), showing the relation between the dark coloured portion and blood-vessels, and also the number of myotomes.

Fig. 16. *Scomber japonicus.*

Fig. 17. *Sarda orientalis.*

Fig. 18. *Neothunnus macropterus.*

Fig. 19. *Katsuwonus pelamis.*

PLATE XVIII.

Cutaneous blood vessels and minute blood vessels connected with them in the dorsal part of the body (demidiagramatic).

Fig. 20. *Thunnus germo.*

Fig. 21. *Thunnus orientalis.*

Fig. 22. *Parathunnus mebachi.*

Fig. 23. *Neothunnus macropterus.*

Fig. 24. *Neothunnus rarus.*

Fig. 25. *Katsuwonus pelamis.*

Fig. 26. *Euthynnus yaito.*

Fig. 27. *Auxis maru.*

PLATE XIX.

Scomber japonicus.

Fig. 28. Variety "hirasaba."

Fig. 29. Variety "gomasaba" or "marusaba" (immature),

Fig. 30. Skeleton. *a.* dorsal surface of the skull. *b.* Ventral surface of the skull *c.* Ventral view of the anterior precaudal vertebrae to the first vertebra with the haemal arch closed. *d.* Dorsal view of the vertebrae of the caudal peduncle.

PLATE XX.

Fig. 31. *Acanthocybium solandri.*

Fig. 32. *Cybium niphonium.*

Fig. 33. *Sarda orientalis.*

PLATE XXI.

Fig. 34. *Cybium chinense.*

Fig. 35. *Cybium koreanum. a.* Ventral view of the skull. *b.* Dorsal view of the skull. *c.* Side view of the skull.

PLATE XXII.

Fig. 36. *Cybium commerson.*

Fig. 37. *Gymnosarda nuda.*

Fig. 38. Skeleton of *Gymnosarda nuda*. *a*. Dorsal view of the skull. *b*. Ventral view of the skull. *c*. Ventral view of anterior precaudal vertebrae to the first vertebra in which the haemal arch is closed. *d*. Dorsal view of the vertebrae of the caudal peduncle.

PLATE XXIII.

Fig. 39. Skeleton of *Acanthocybium solandri*. *a*. Dorsal view of the skull. *b*. Ventral view of the skull. *c*. Ventral view of anterior precaudal vertebrae to the first vertebra with the closed haemal arch. *d*. Dorsal view of the vertebrae of the caudal peduncle.

Fig. 40. Skeleton of *Cybium chinense*. *a*. Dorsal view of the skull. *b*. Ventral view of the skull with following vertebrae. *c*. Dorsal view of vertebrae of the caudal peduncle.

PLATE XXIV.

Fig. 41. Skeleton of *Cybium niphonium*. *a*. Dorsal view of the skull. *b*. Ventral view of the skull and precaudal vertebrae. *c*. Dorsal view of vertebrae of the caudal peduncle.

Fig. 42. Skeleton of *Sarda orientalis*. *a*. Dorsal view of the skull. *b*. Ventral view of the skull. *c*. Ventral view of anterior precaudal vertebrae. *d*. Dorsal view of vertebrae of the caudal peduncle.

PLATE XXV.

Fig. 43. *Thunnus orientalis*. Immature specimen, about six months old.

Fig. 44. Skelton of the above.

PLATE XXVI.

Fig. 45. *Neothunnus macropterus*. (Immature).

Fig. 46. *Thunnus germo*.

PLATE XXVII.

Fig. 47. *Parathunnus mebachi*. (Immature).

Fig. 48. *Neothunnus rarus*.

PLATE XXVIII.

Fig. 49. Skull and vertebral column of *Parathunnus mebachi*,.

Fig. 50. Skull and vertebral column of *Thunnus orientalis*.

a. Dorsal view of the skull. *b*. Ventral view of the skull. *c*. Ventral view of the anterior vertebrae till the first haemal arch is closed. Anterior Zygapophyses of the second vertebra are represented in *Th. orientalis* only. *d*. Dorsal view of the caudal vertebrae. (*Th. orientalis*, ventral view?)

PLATE XXIX.

Fig. 51. Skull and vertebral column of *Neothunnus macropterus*..

Fig. 52. Skull and vertebral column of *Thunnus germo*.

a, b, c, d. The same as in the preceding plate.

PLATE XXX.

Fig. 53. *Katsuwonus pelamis.*

Fig. 54. *Euthynnus yaito.*

PLATE XXXI.

Fig. 55. *Auxis hira.*

Fig. 56. *Auxis maru.*

PLATE XXXII.

Fig. 57. Skull and vertebral column of *Katsuwonus pelamis.*

Fig. 58. Skull and vertebral column of *Euthynnus yaito.*

a. Dorsal view of the skull. *b.* Ventral view of the skull. *c.* Ventral view of the anterior vertebrae, till the first haemal arch is closed. *d.* Dorsal view of the caudal vertebrae. *e, f, g.* Three stages of haemal processes till they unite to form the haemal canal in precaudal vertebrae.

PLATE XXXIII.

Fig. 59. Skull and vertebral column of *Auxis hira.*

Fig. 60. Skull and vertebral column of *Auxis maru.*

a. Dorsal view of the skull. *b.* Ventral view of the skull. *c.* Ventral view of the vertebral column to the first caudal vertebra, in which the haemal arch is closed. *d.* Dorsal view of the caudal vertebrae in which the lateral process or ridge is more or less developed. *e, f, g.* Three stages of the development of the haemal processes in the precaudal vertebrae. In the last stage the epihaemal process is remarkably developed.

PLATE XXXIV.

Fig. 61. *Cybium guttatum.*

Fig. 62. *Grammatorcynus bilineatus.*

Fig. 63. *Rastrelliger chrysozonus.*

Fig. 64. Skull and vertebral column of *Neothunnus rarus.*

a. Dorsal view of the skull. *b.* Ventral of the skull. *c.* Ventral view of the anterior vertebrae till the first haemal arch is closed. *d.* Dorsal view of the caudal vertebrae.

Index to the Vernacular Names.

Index.

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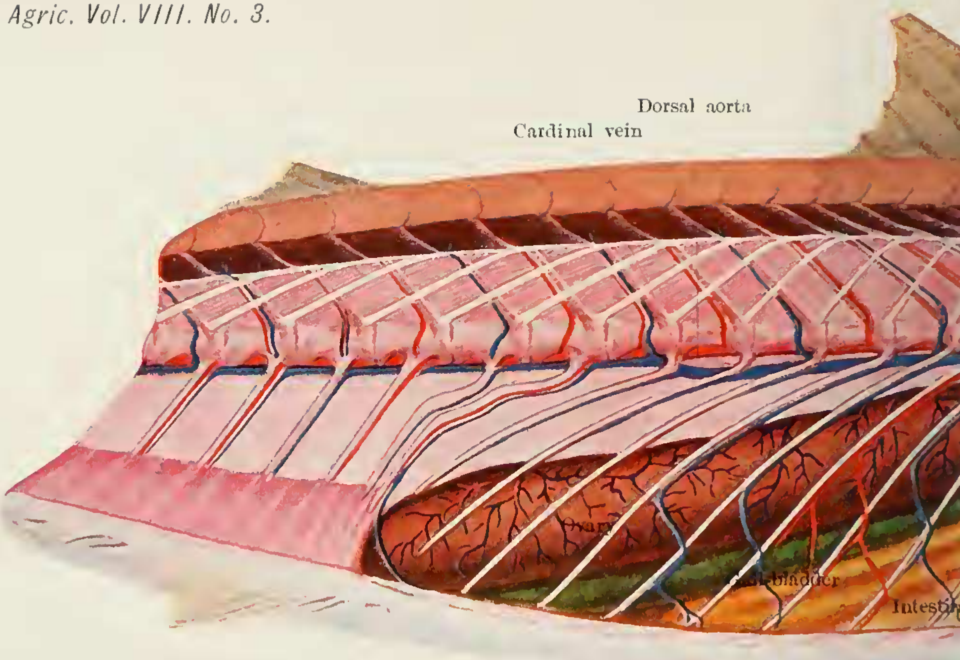
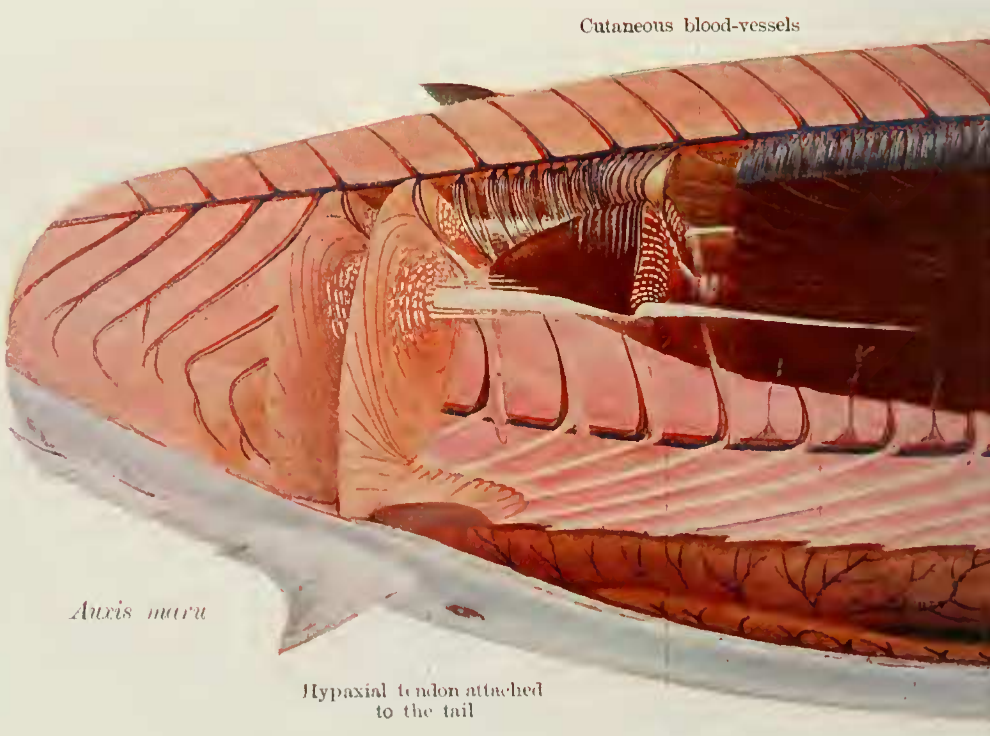


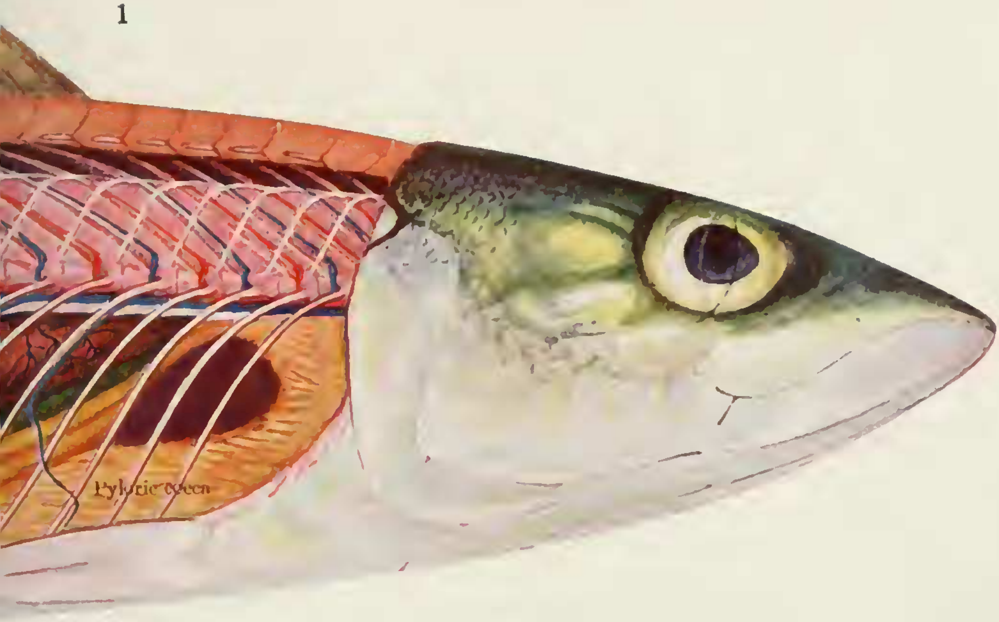
Scomber japonicus



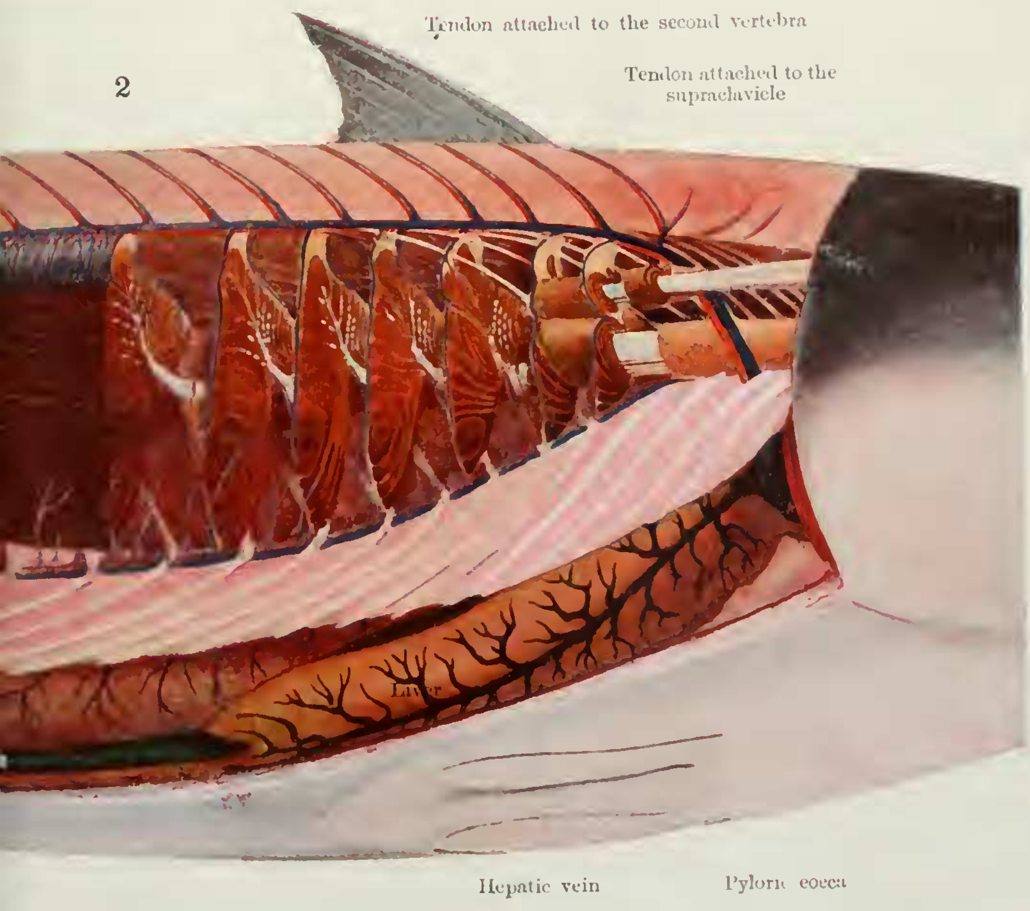
Auxis maru

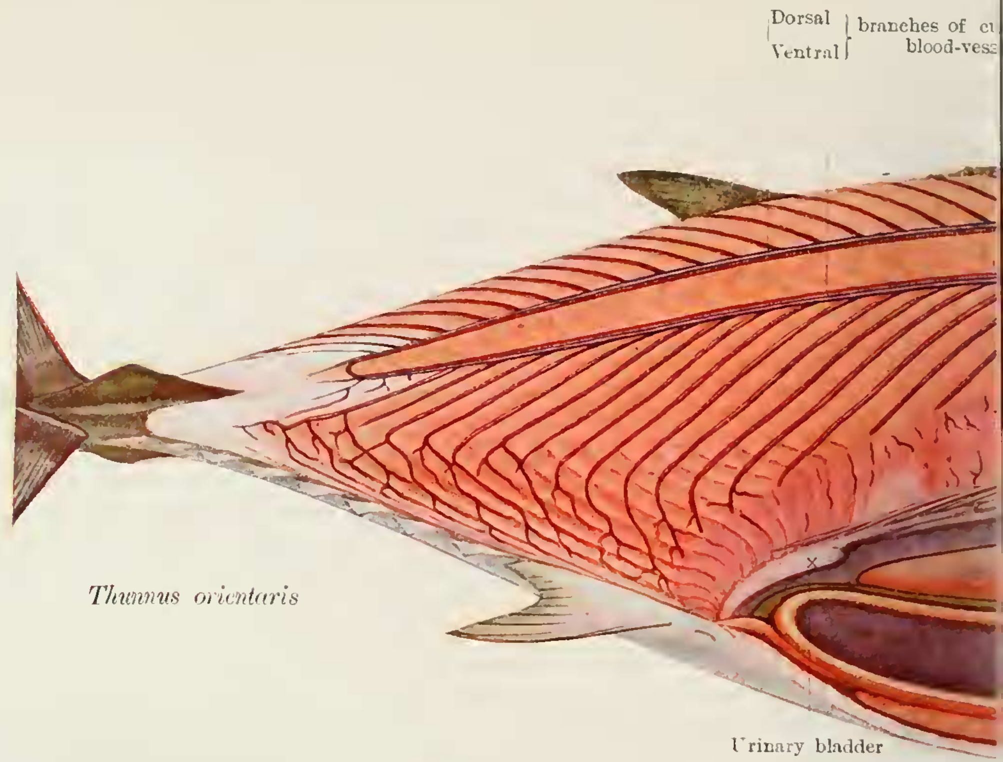
S. Kikkawa del.

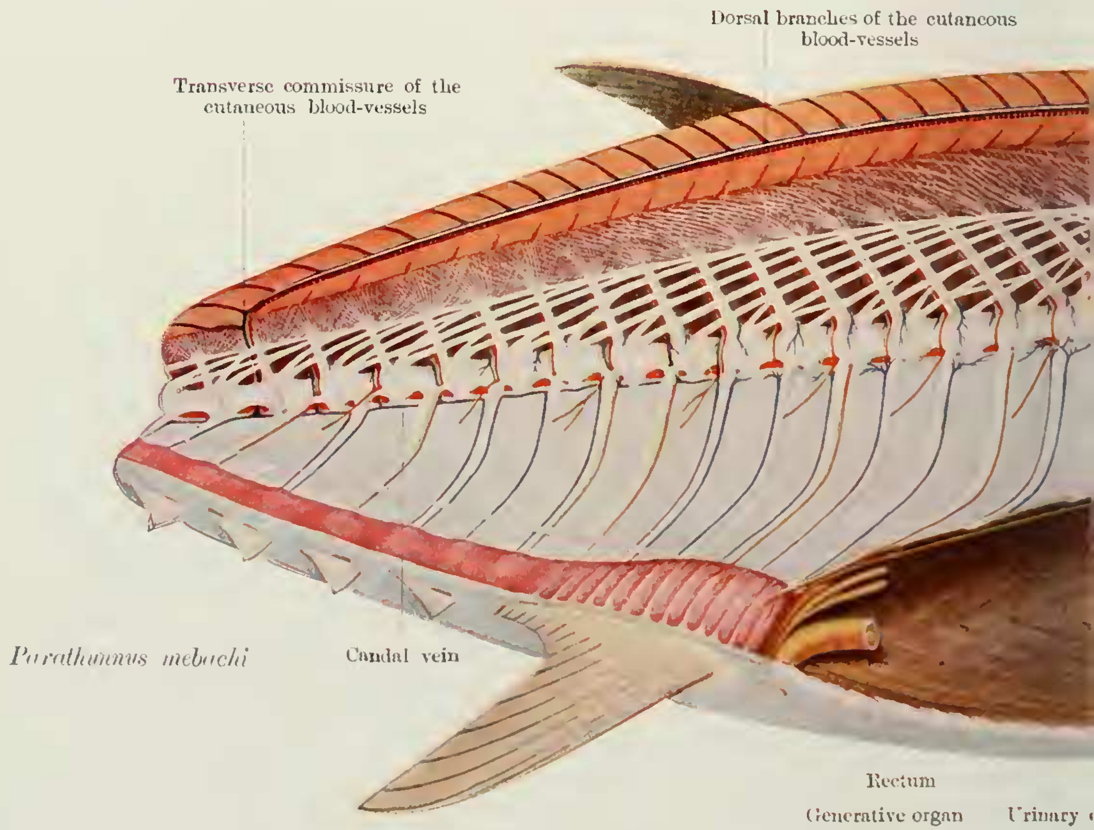
1


Pyloric coeca

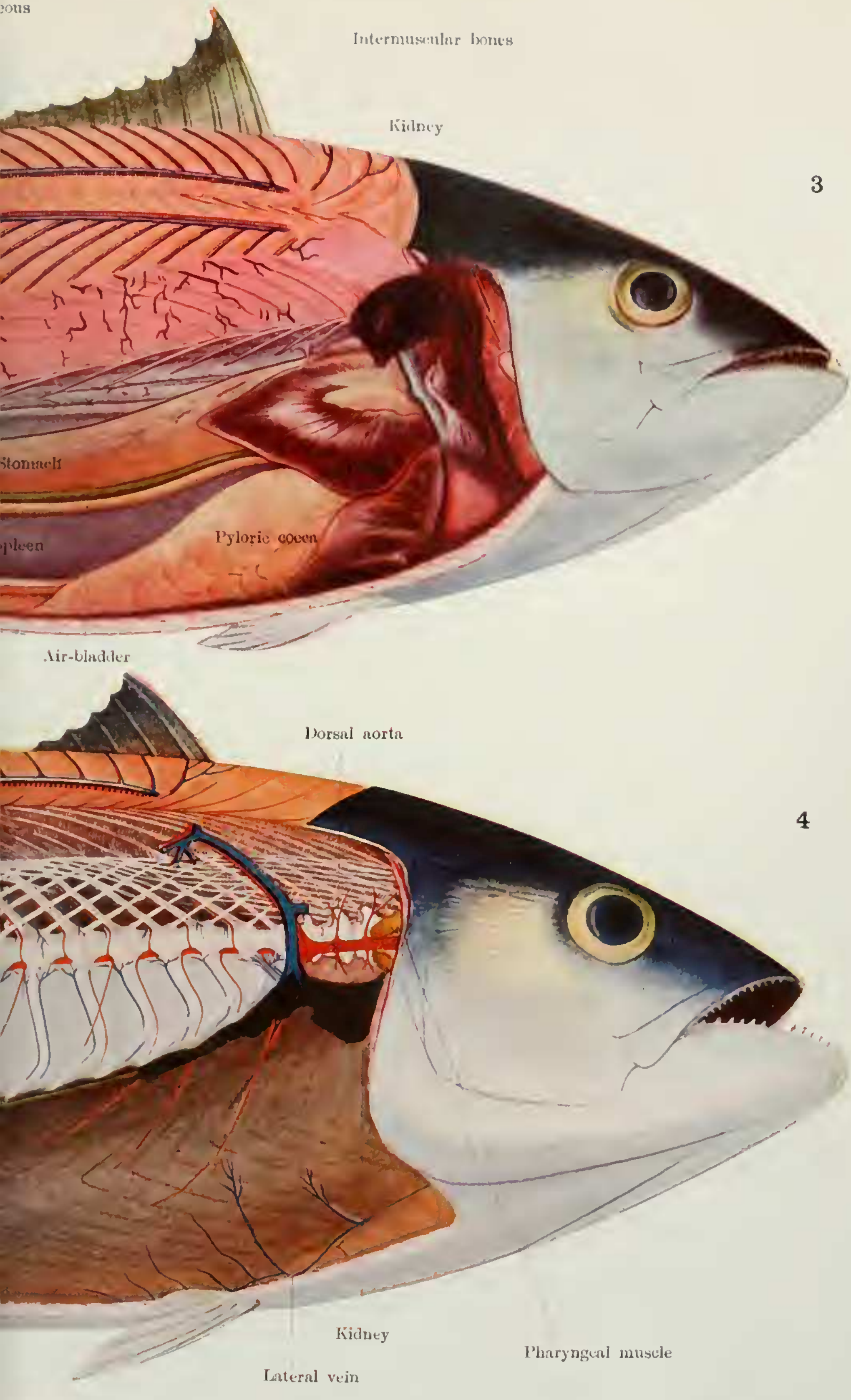
2

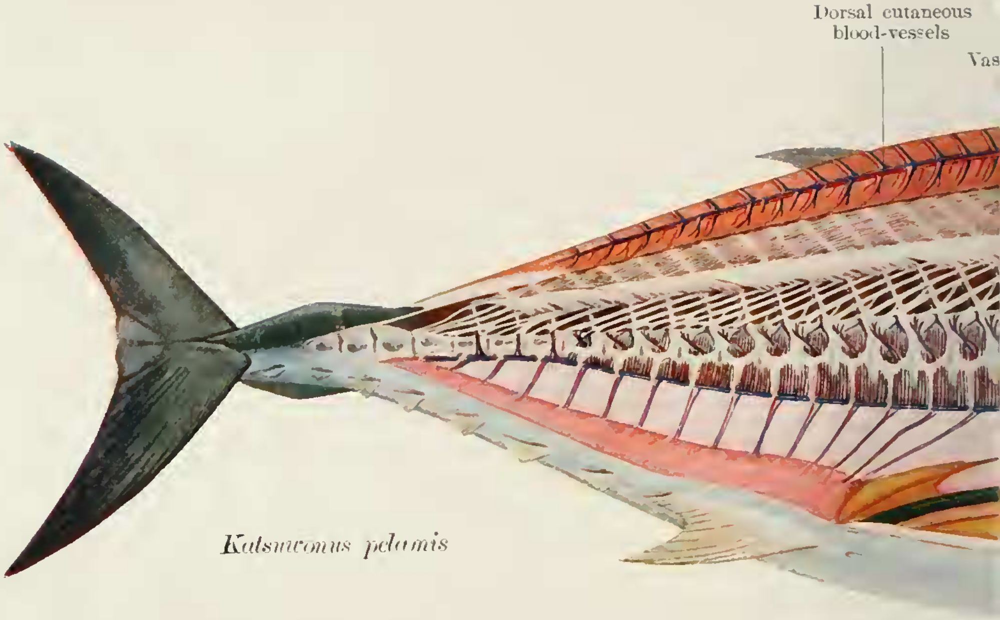

Tendon attached to the second vertebra
Tendon attached to the supraclavicle
Liver
Hepatic vein
Pyloric coeca



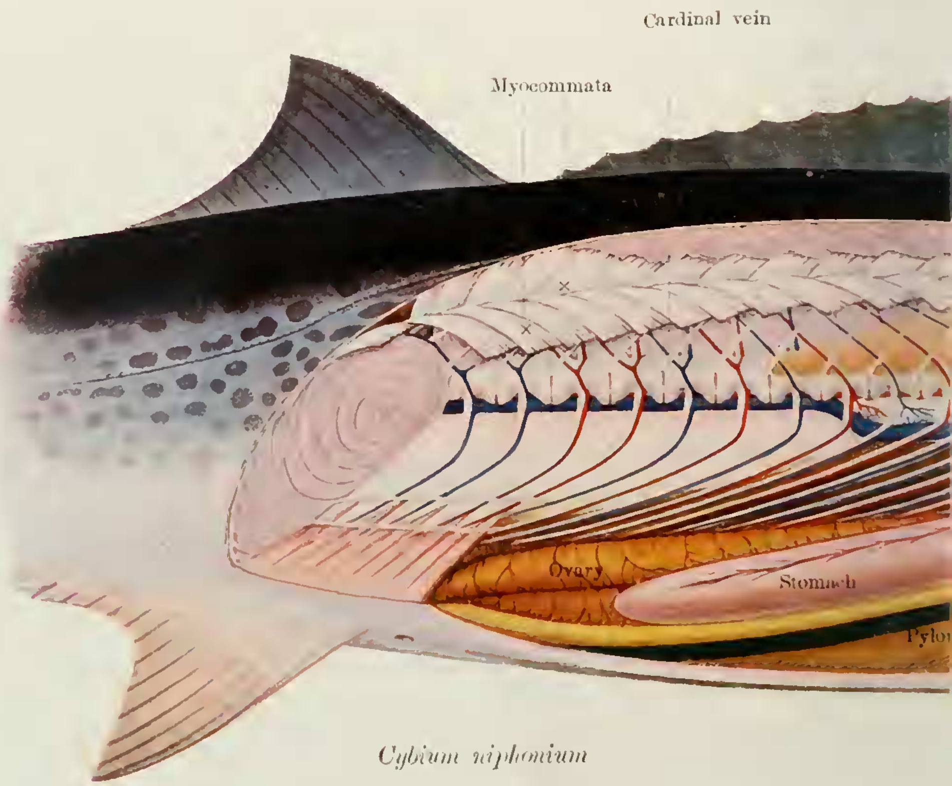


S. Kikkawa del.


eous
Intermuscular bones
Kidney
3
Stomach
Pyloric coeca
pleen
Air-bladder
Dorsal aorta
4
Kidney
Pharyngeal muscle
Lateral vein

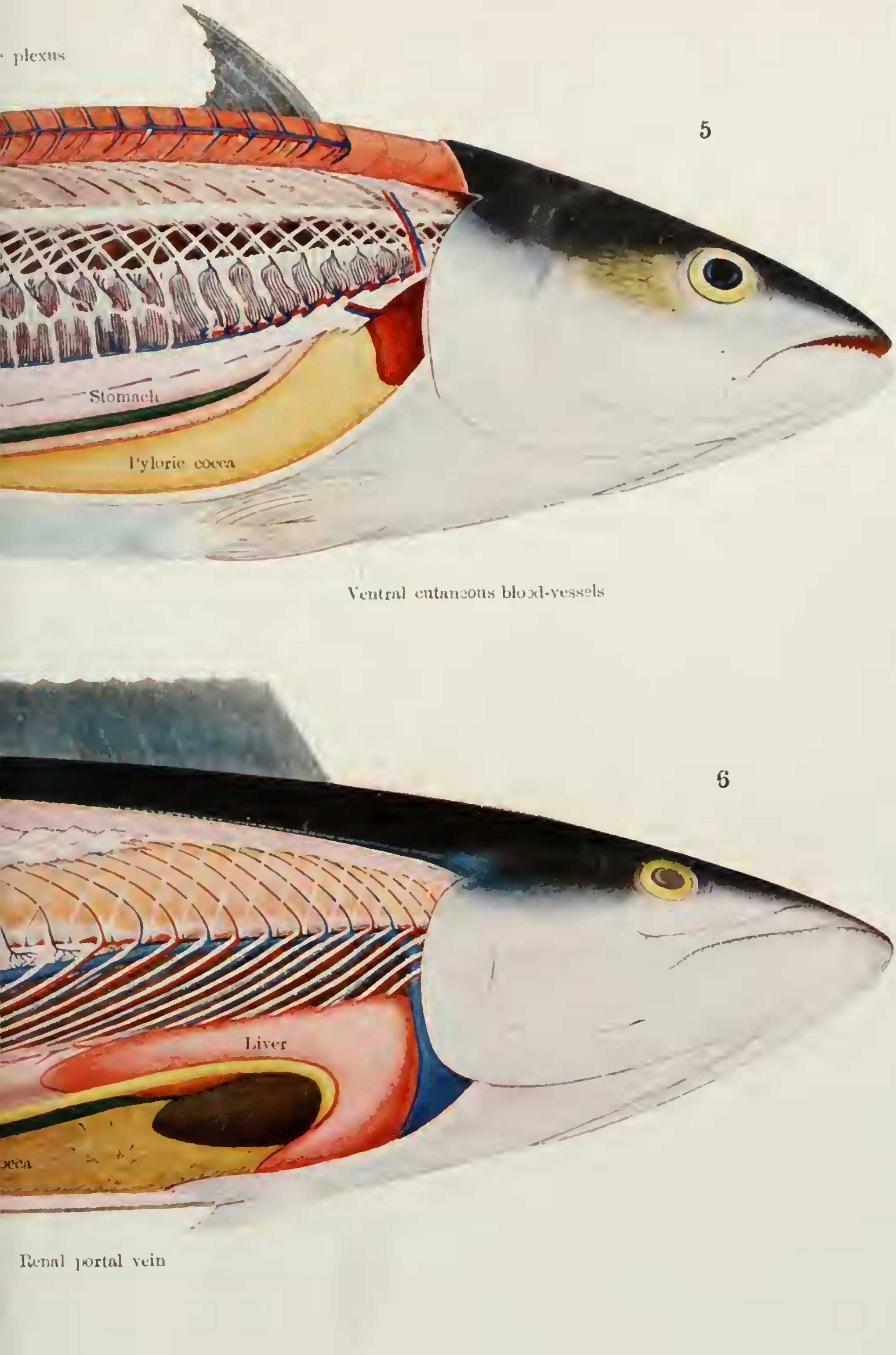


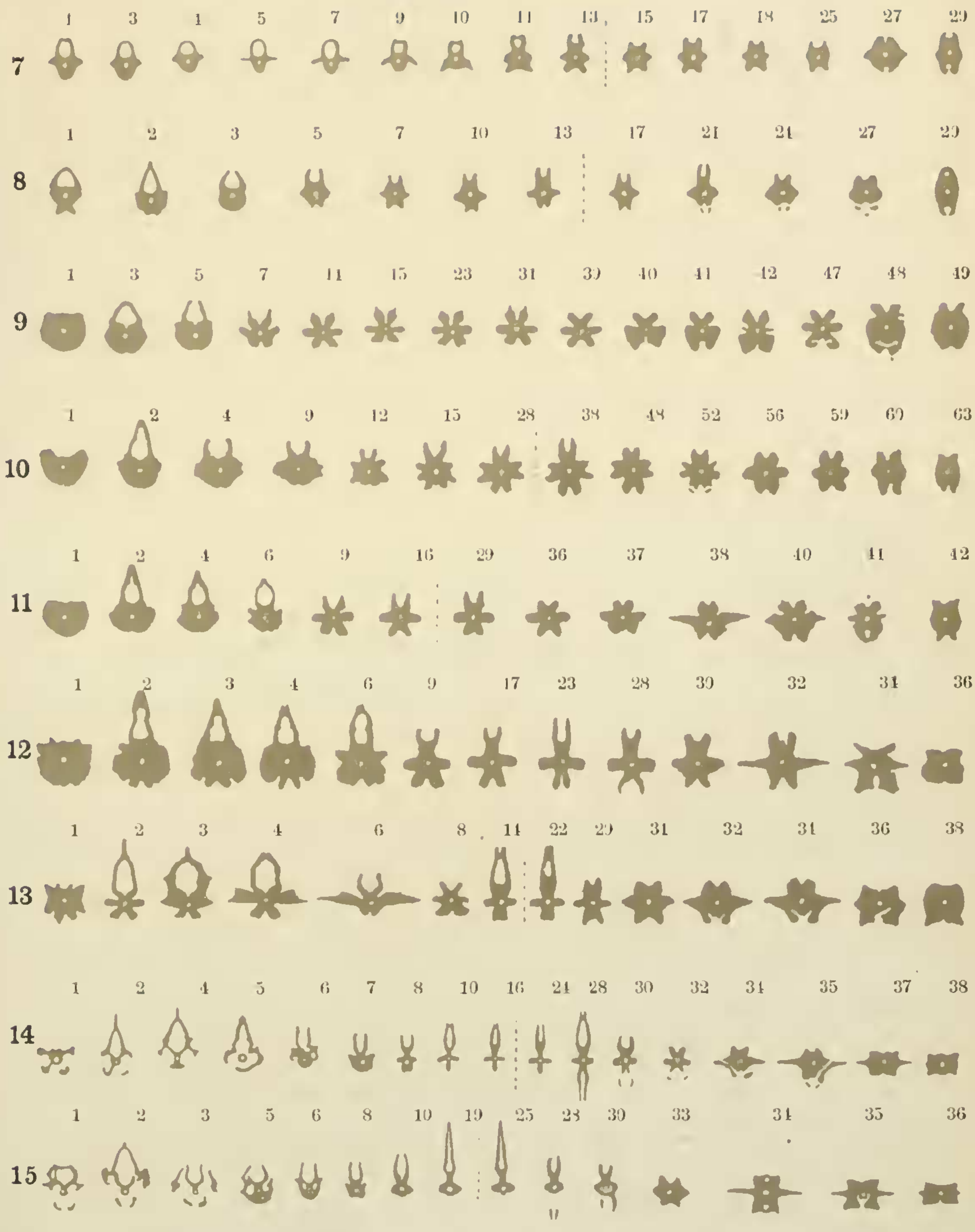
Katsuwonus pelamis



Cybium niphonium

S. Kikkawa del.


plexus
5
Stomach
Pyloric cœca
Ventral cutaneous blood-vessels
6
Liver
œca
Renal portal vein

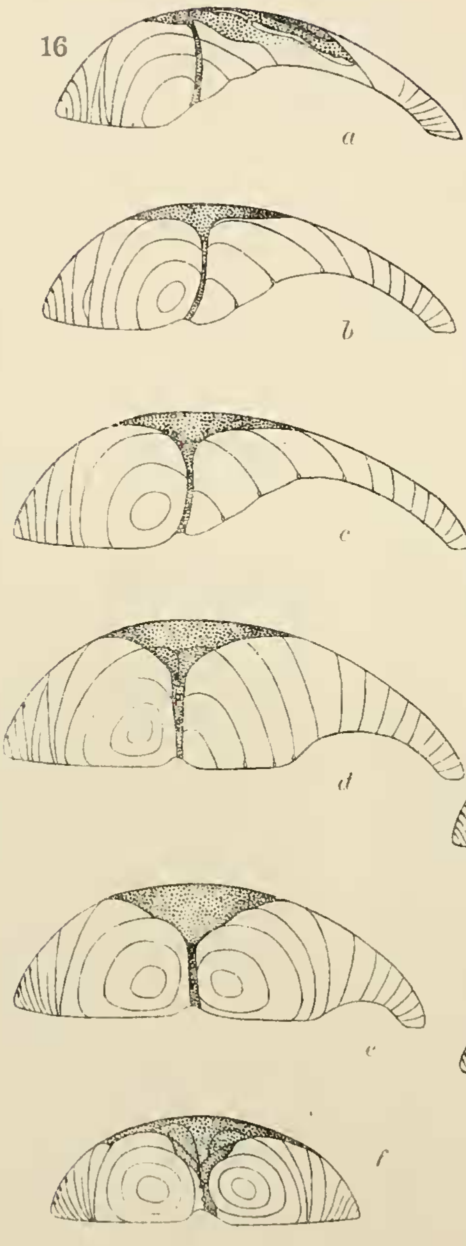


Middle Transverse Section of Vertebrae,

7. *Scomber japonicus* (14 + 17).
8. *Grammatorcynus bilineatus* (13 + 18).
9. *Cybium niphonium* (22 + 28).
10. *Acanthocybium solandri* (33 + 31).
11. *Sarda orientalis* (25 + 20).
12. *Gymnosarda nuda* (19 + 19).
13. *Neothunnus macropterus* (18 + 21).
14. *Katsuwonus pelamis* (20 + 21).
15. *Auxis maru* (20 + 19).

A dotted line separates the caudal vertebrae from the precaudal, and the numerals in a smaller type denote the ordinal number of vertebrae, counted from the anterior end.

16



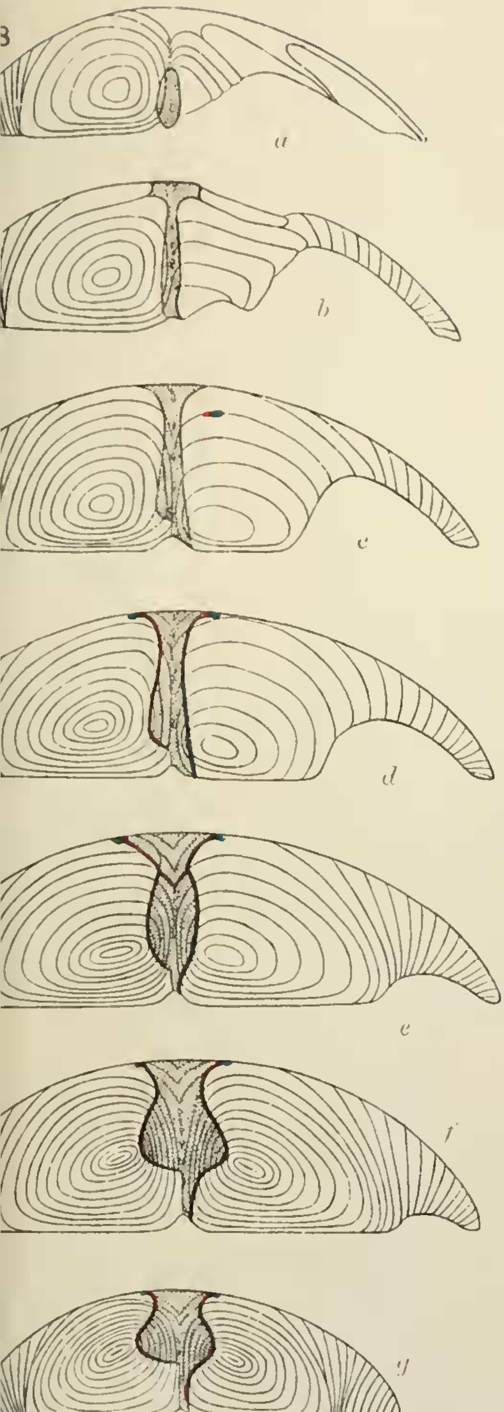
Scomber japonicus

17

Sarda orientalis

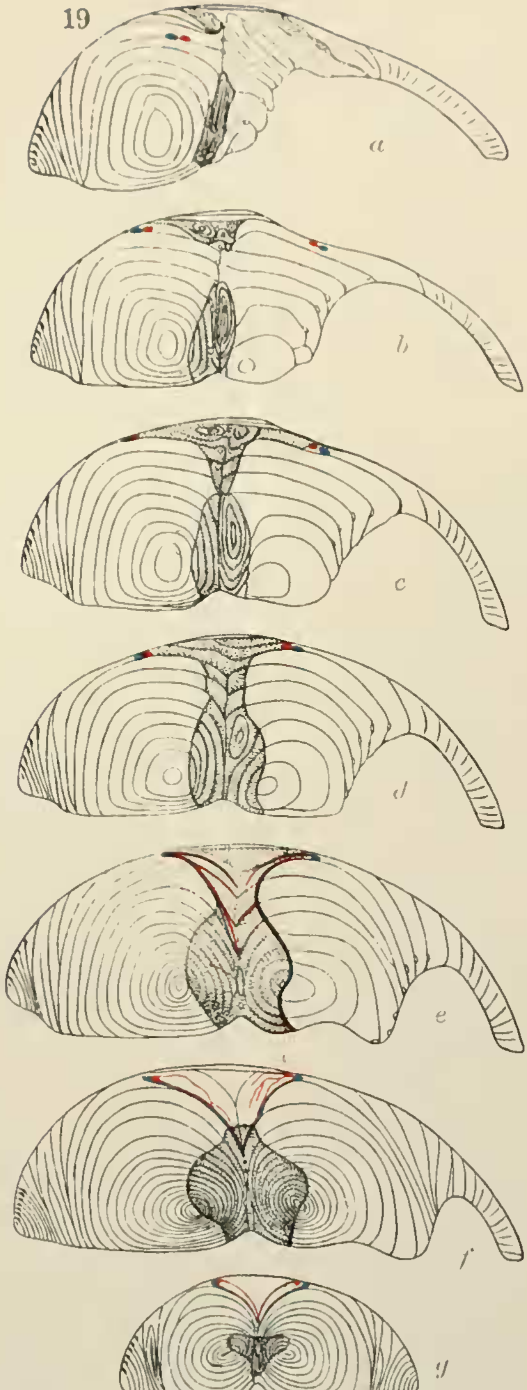
Cross-sections of the lateral muscle and the dorsal and
dark coloured portion and blooc

8



Neothunnus macropterus

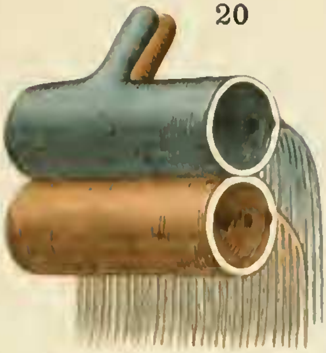
19



Katsuwonus pelamis

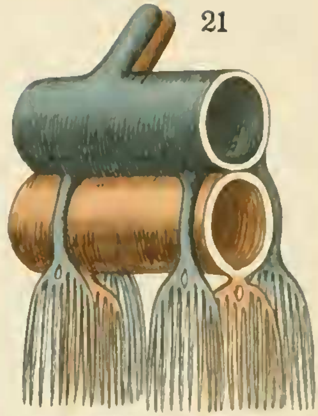
tral carinales (one half moiety), showing the relation between the
ssels, and also the number of myotomoes.

20



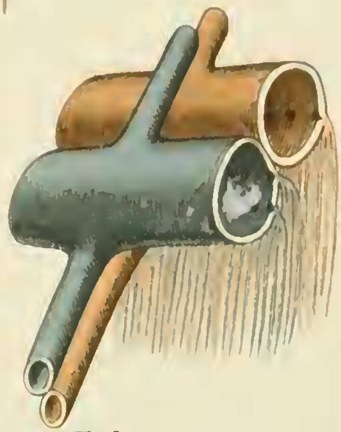
Thunnus germo.

21



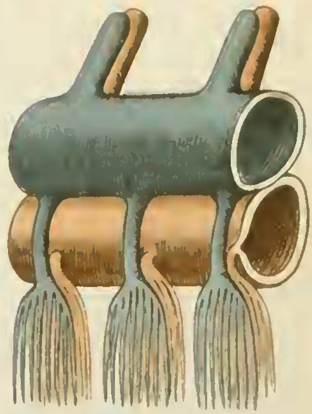
Thunnus orientalis.

26



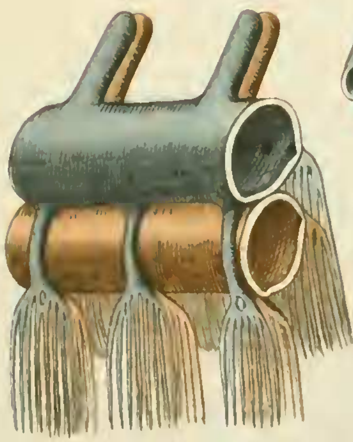
Euthynnus yaito.

23



Neothunnus macropterus.

22

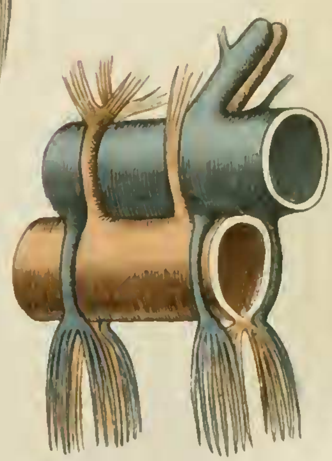


Parathunnus mebachi.

27

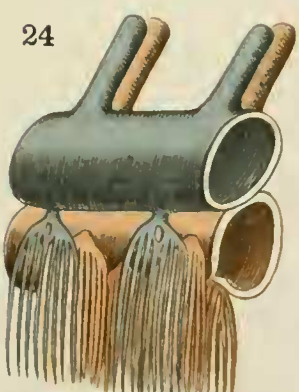
Auxis maru.

25



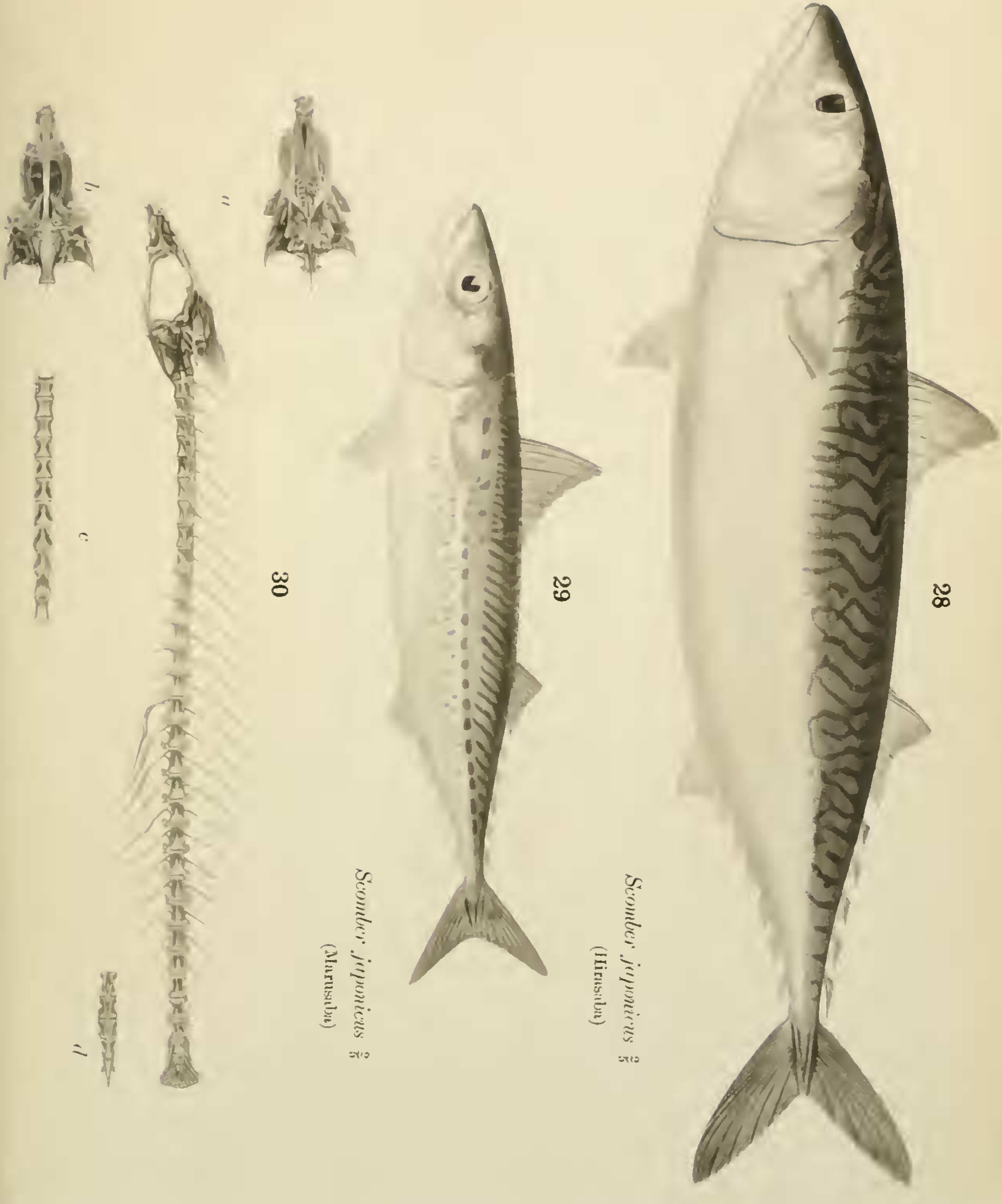
Katsuwonus pelamis.

24



Neothunnus rarus.

Cutaneous blood-vessels (expaxial) and vascular plexus connected with them. Magnified.



S. Kikkawa del.

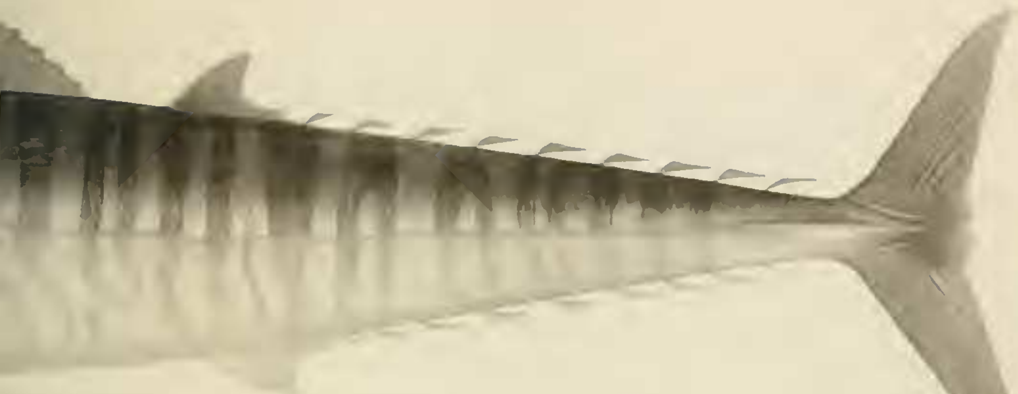
31

32

Cybium niphonium ¼

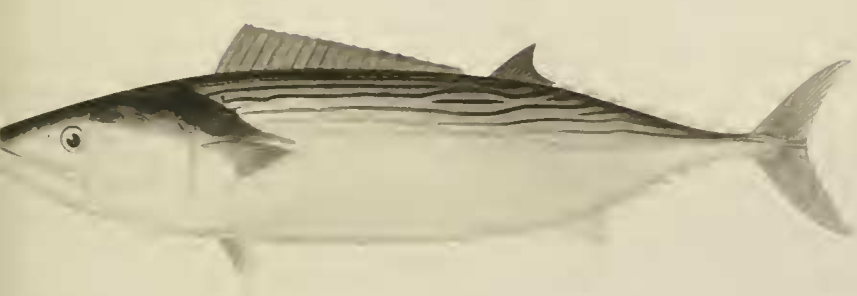
33

S. Kikkawa del.

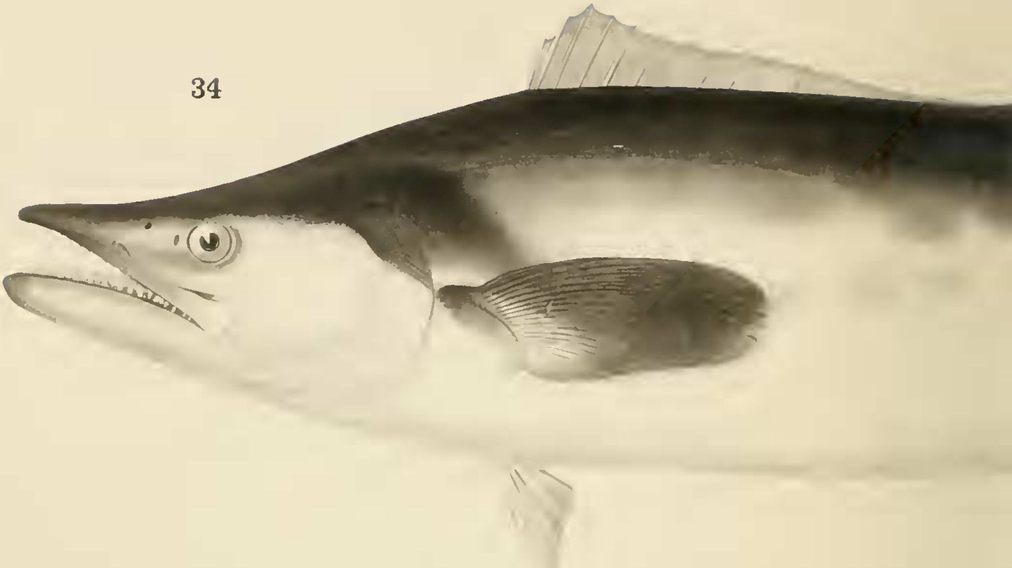


Acanthocybium solandri ¼

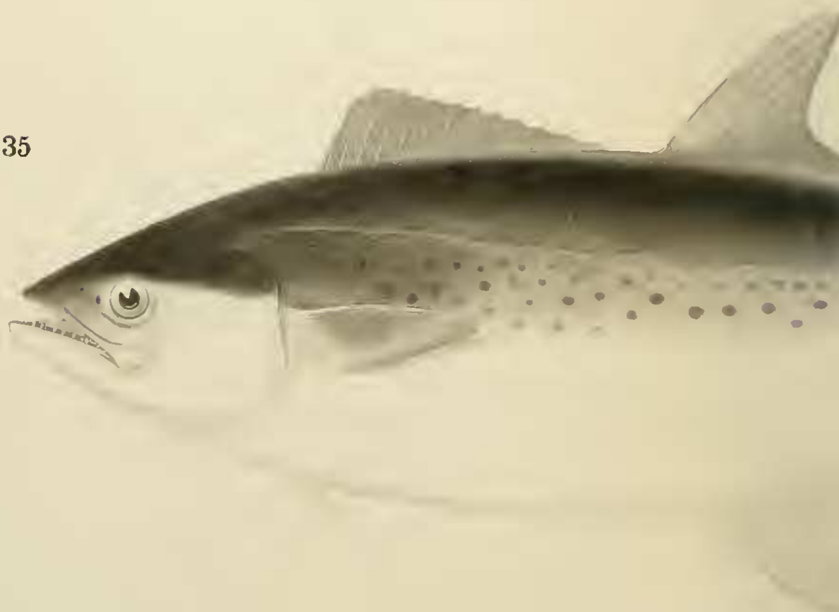
Sarda orientalis ¼



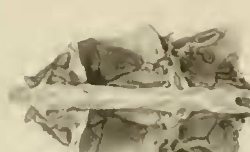
34



35

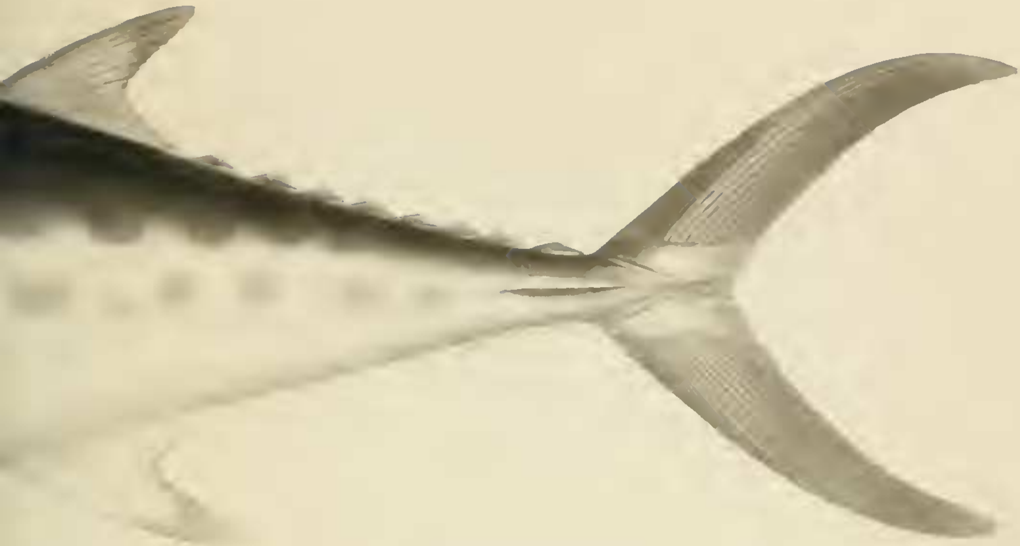


a



b

S. Kikkawa del.



Cybium chinense $\frac{1}{4}$

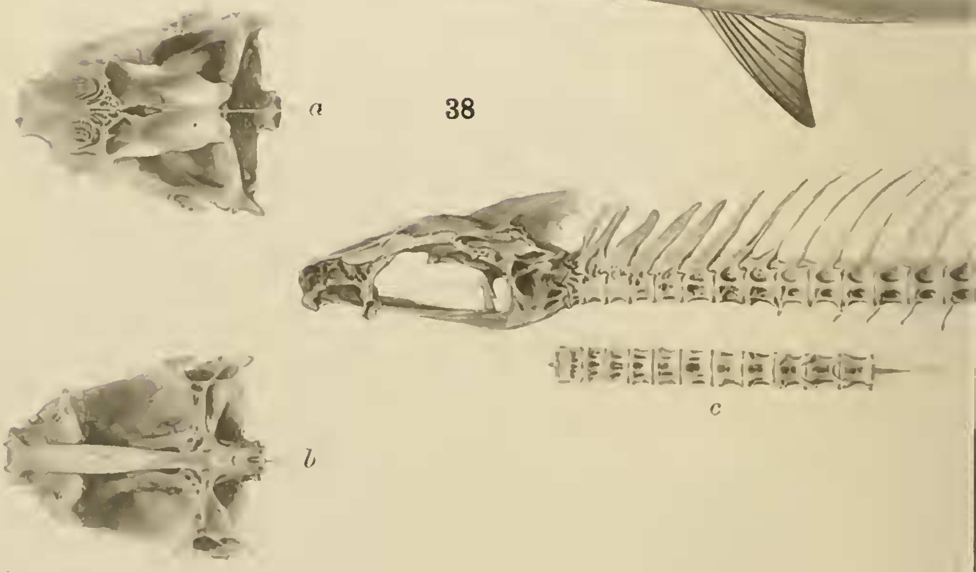
Cybium koreanum $\frac{10}{27}$

c

36

37

38



S. Kikkawa del.

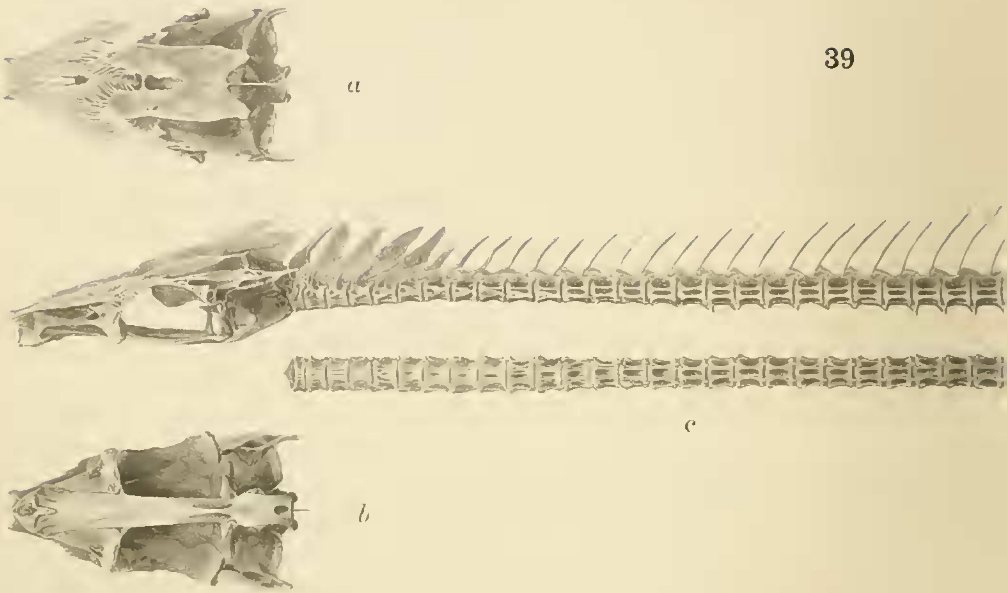
Cybium commerson ⅕

Gymnosarda nuda ⅕

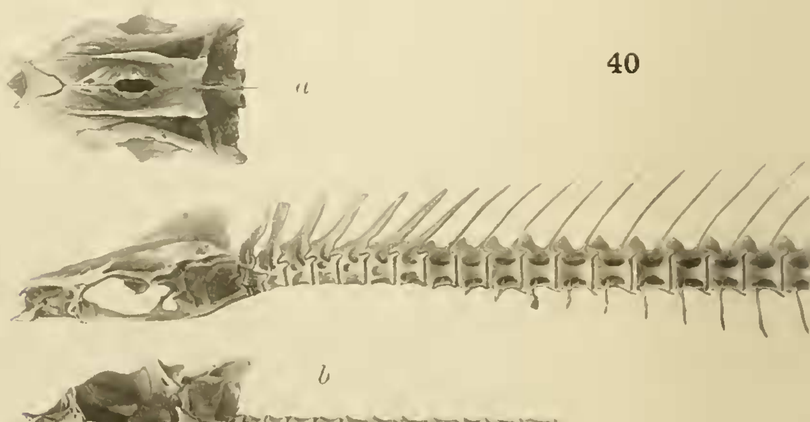
d

Gymnosarda nuda ⅕

39

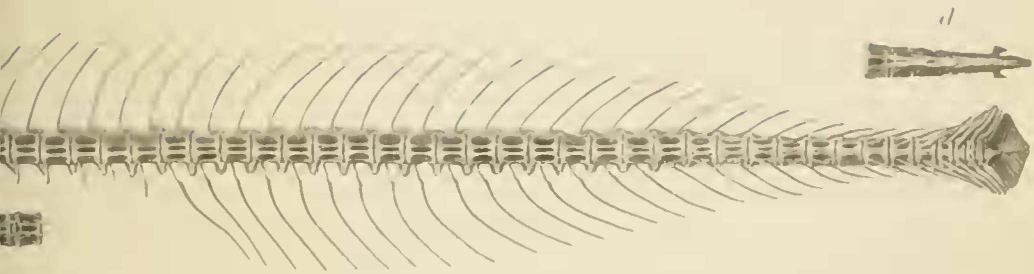


40

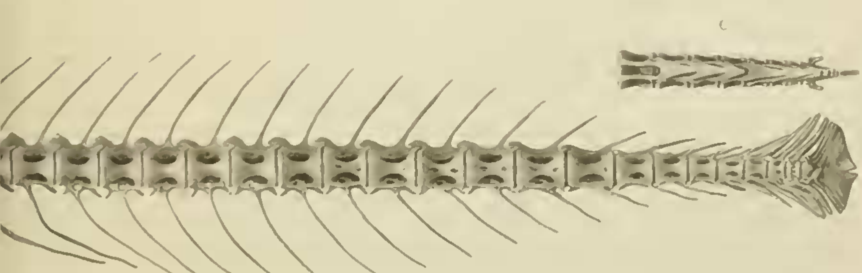


S. Kikkawa del.

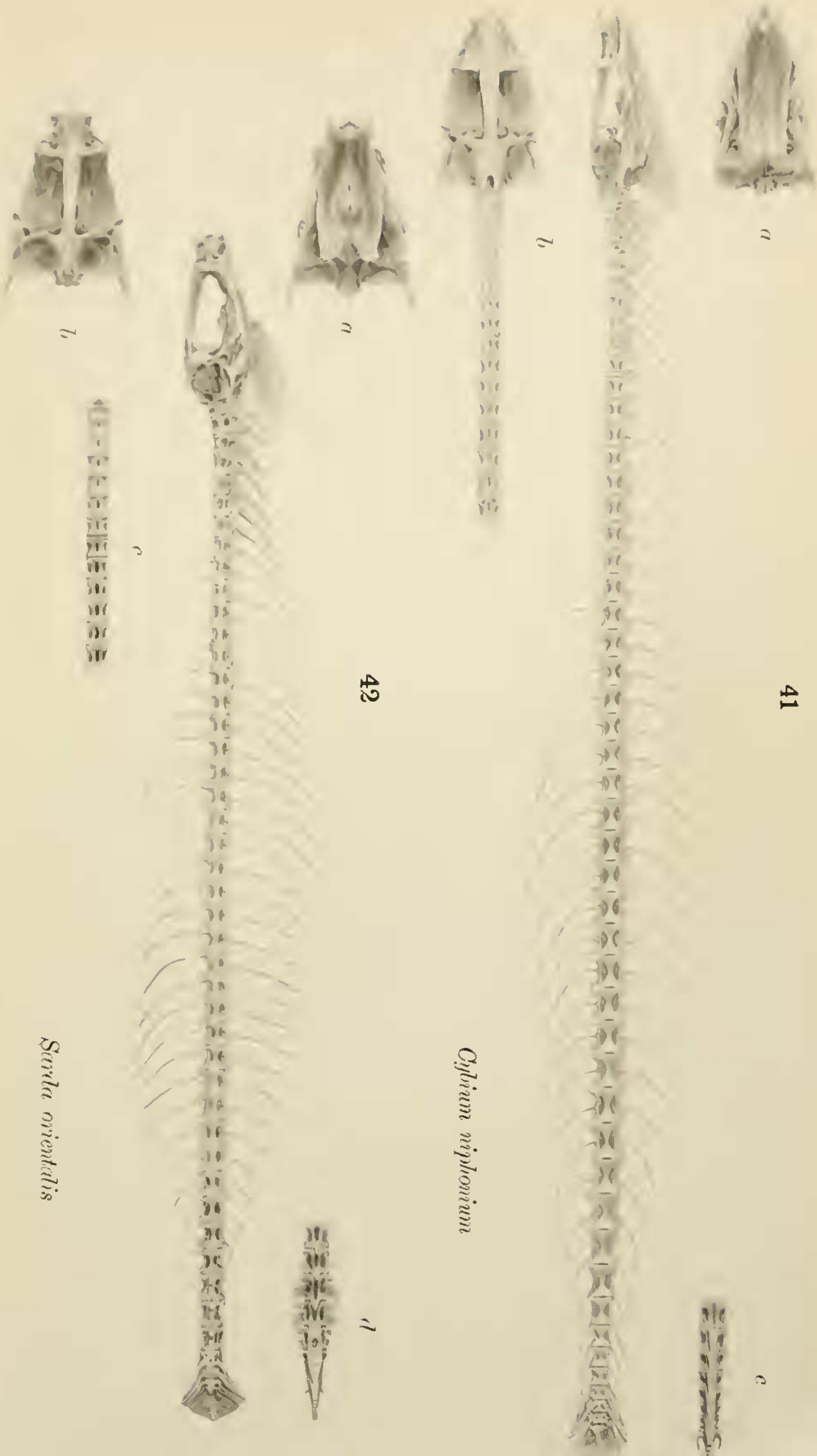
Pl. XXIII.



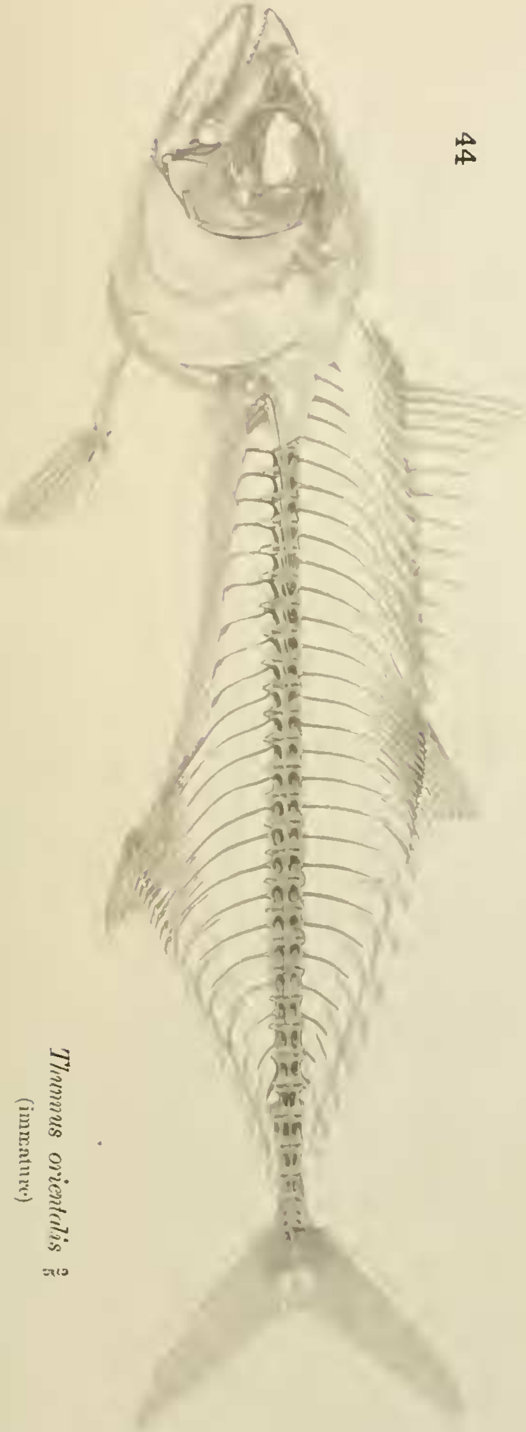
Acanthocybium solandri



Cybium chinense



S. Kikkawa del.



44

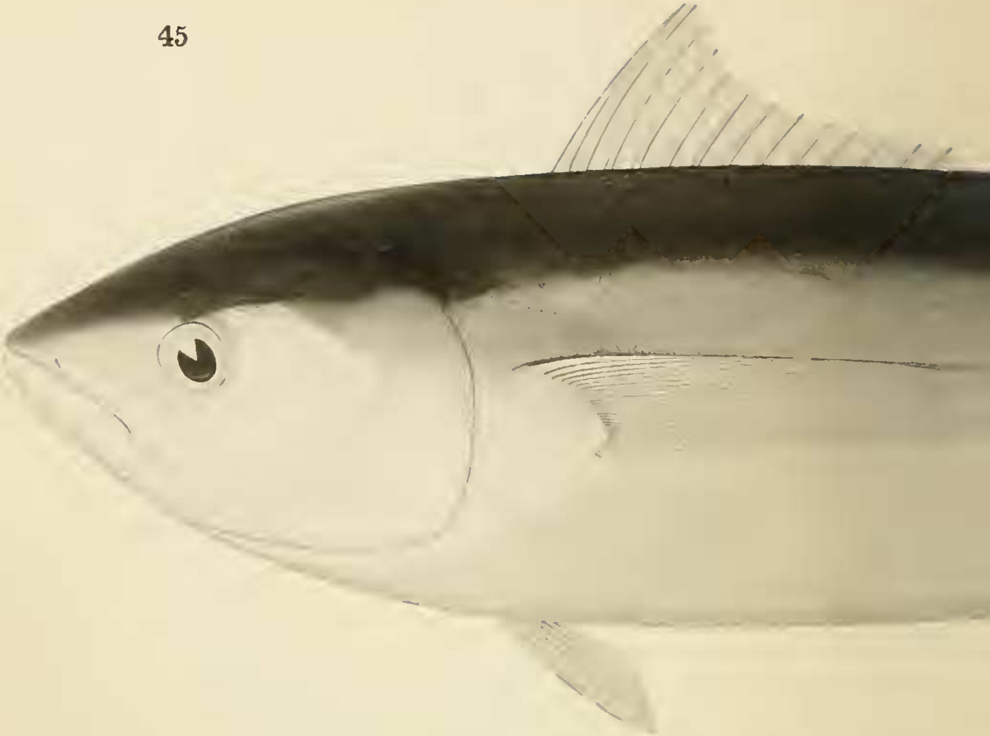
Thunnus orientalis ♀
(immature)

43

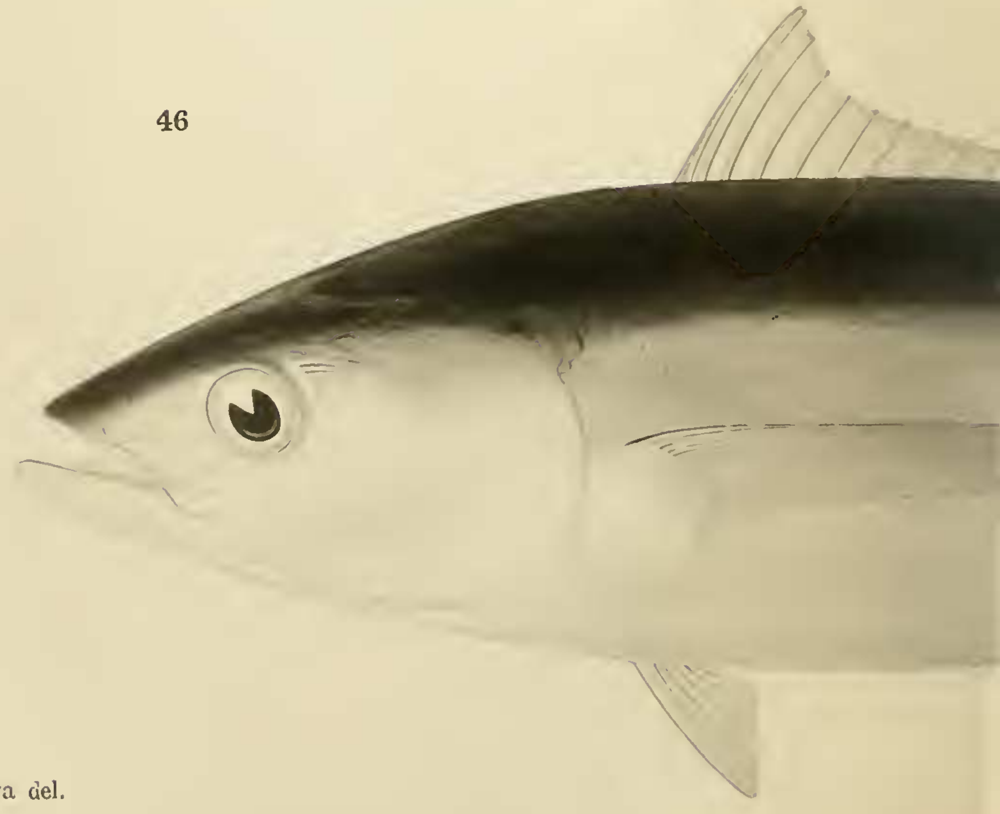
Thunnus orientalis ♀
(immature)

S. Kikkawa del.

45



46

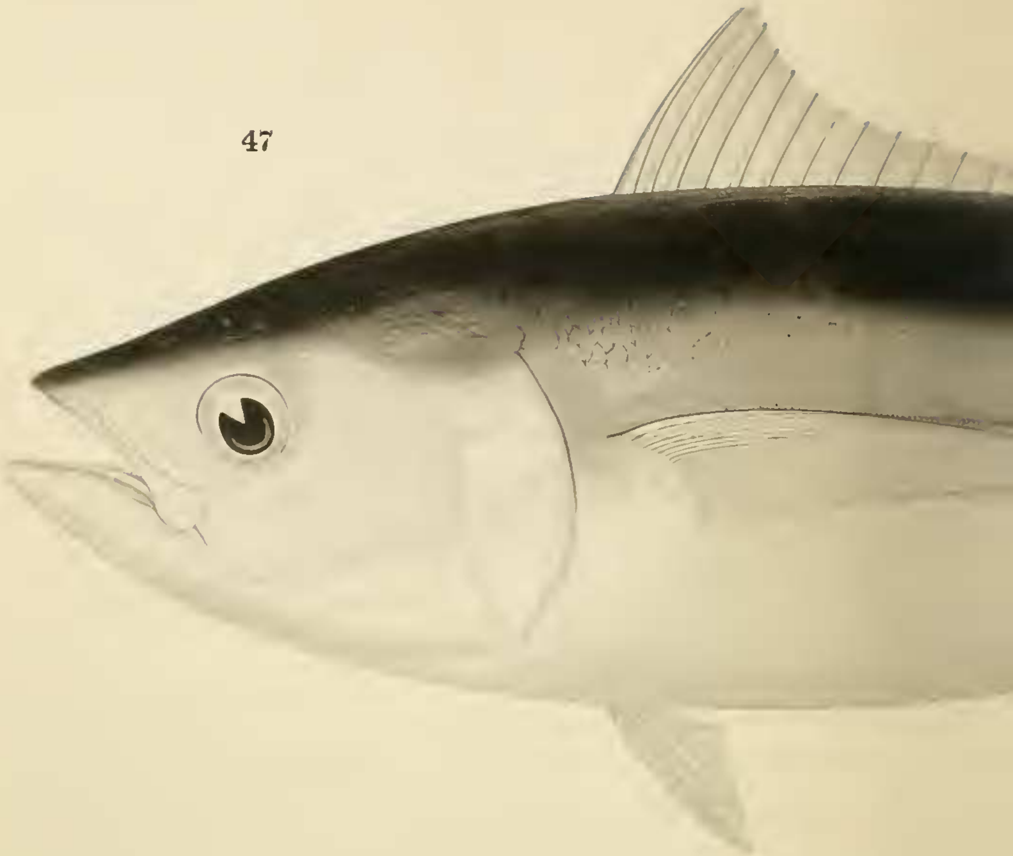


S. Kikkawa del.

Neothunnus macropterus ⅓
(immature)

Thunnus germo ⅓

47



48

S. Kikkawa del.

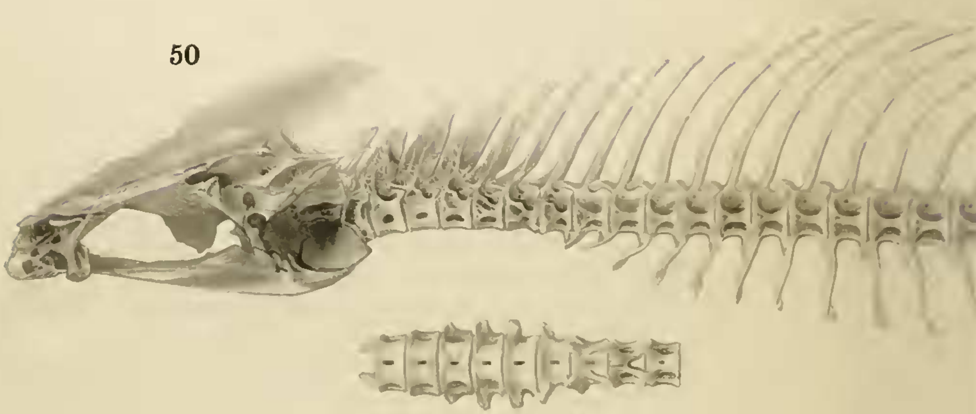
Parathunnus mebachi $\frac{1}{3}$
(immature)

Neothunnus rarus $\frac{1}{3}$

49

c

50



c

S. Kikkawa del.

50 *a*

50 *b*

Parathunnus mebachi ¼

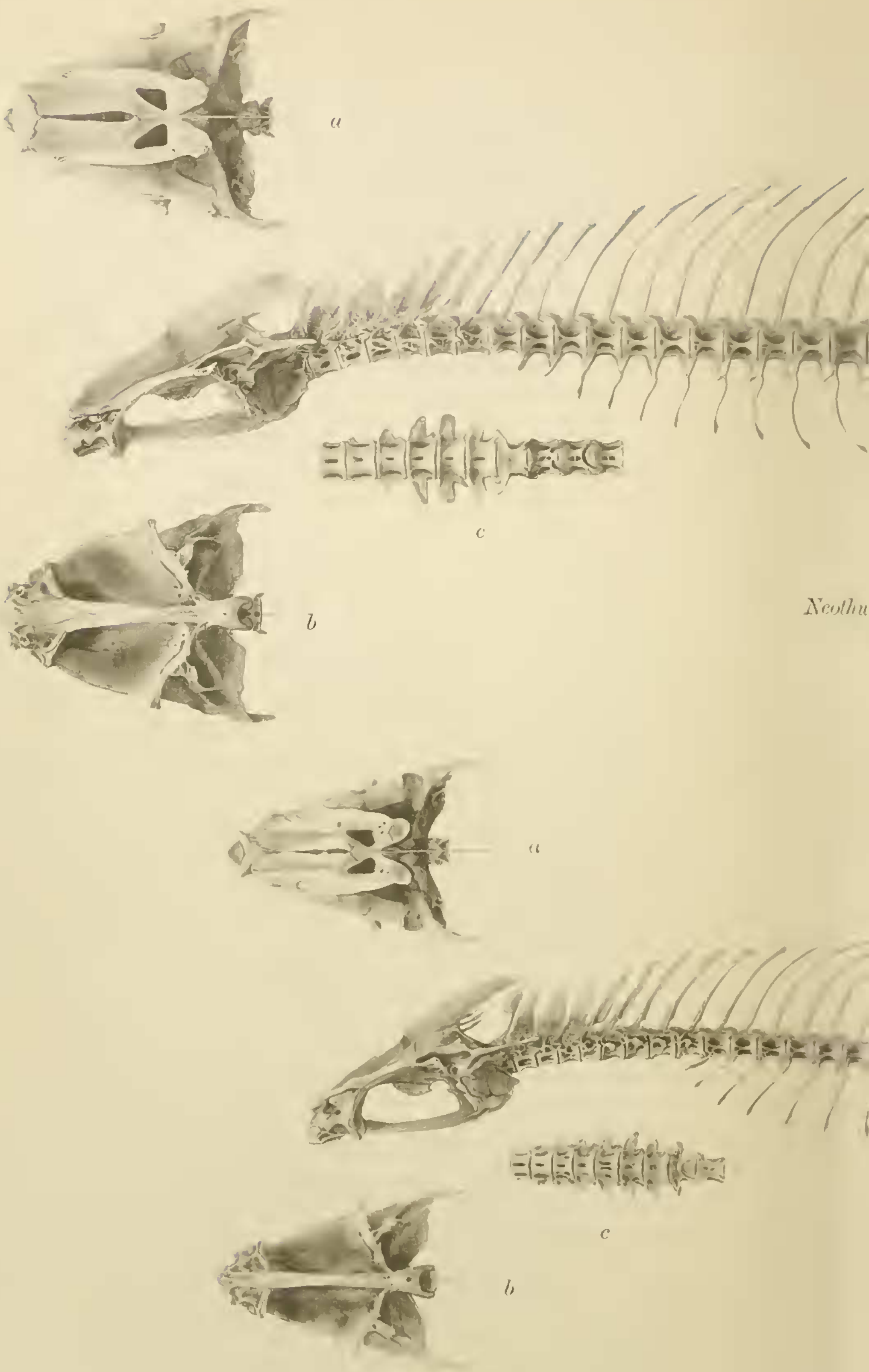
d

Thunnus orientalis ¼

d

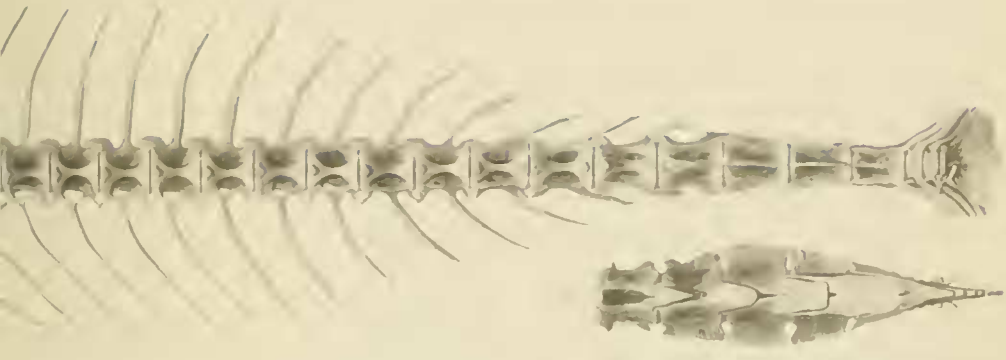
49 a

49 b



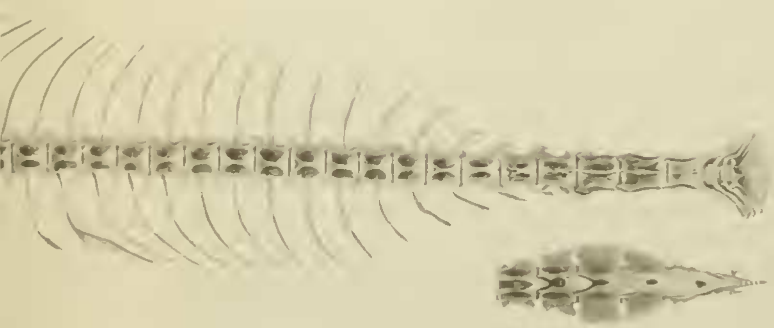
S. Kikkawa del.

51

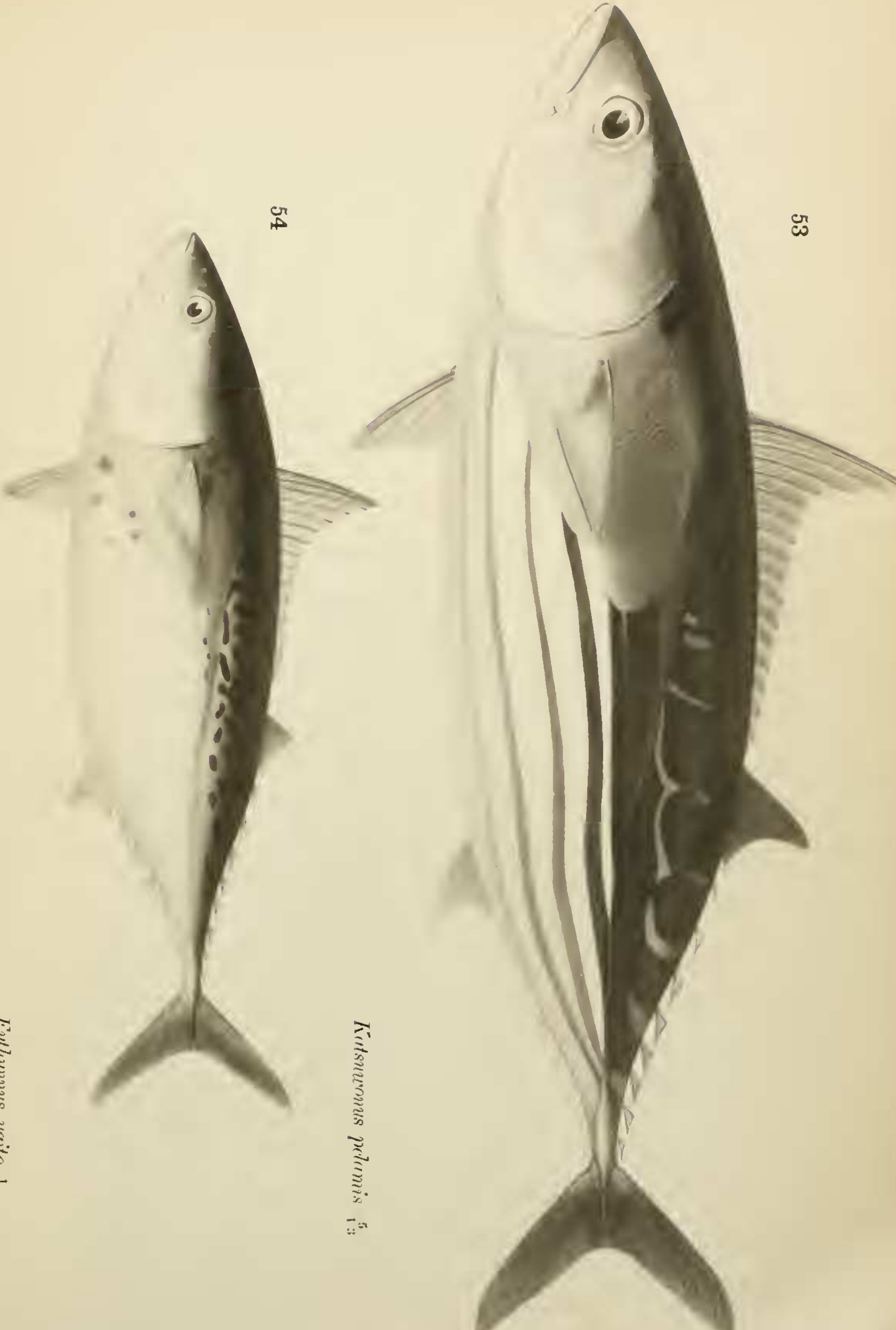


macropterus

52



Thunnus germo



53 *Katsuwonus pelamis* $\frac{5}{13}$

54 *Euthynnus yaito* $\frac{1}{3}$

S. Kikkawa del.

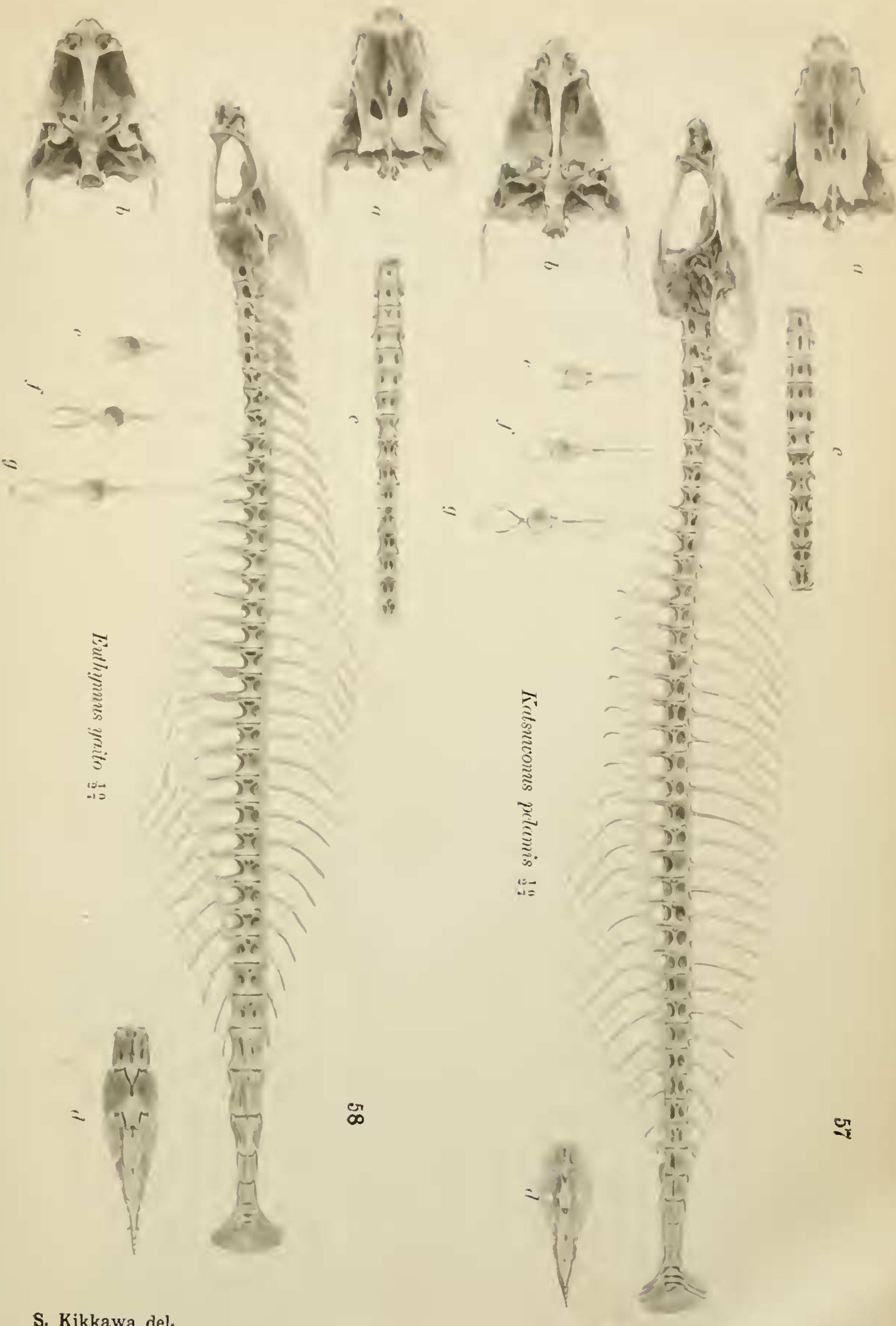
56

Auxis maru × 5

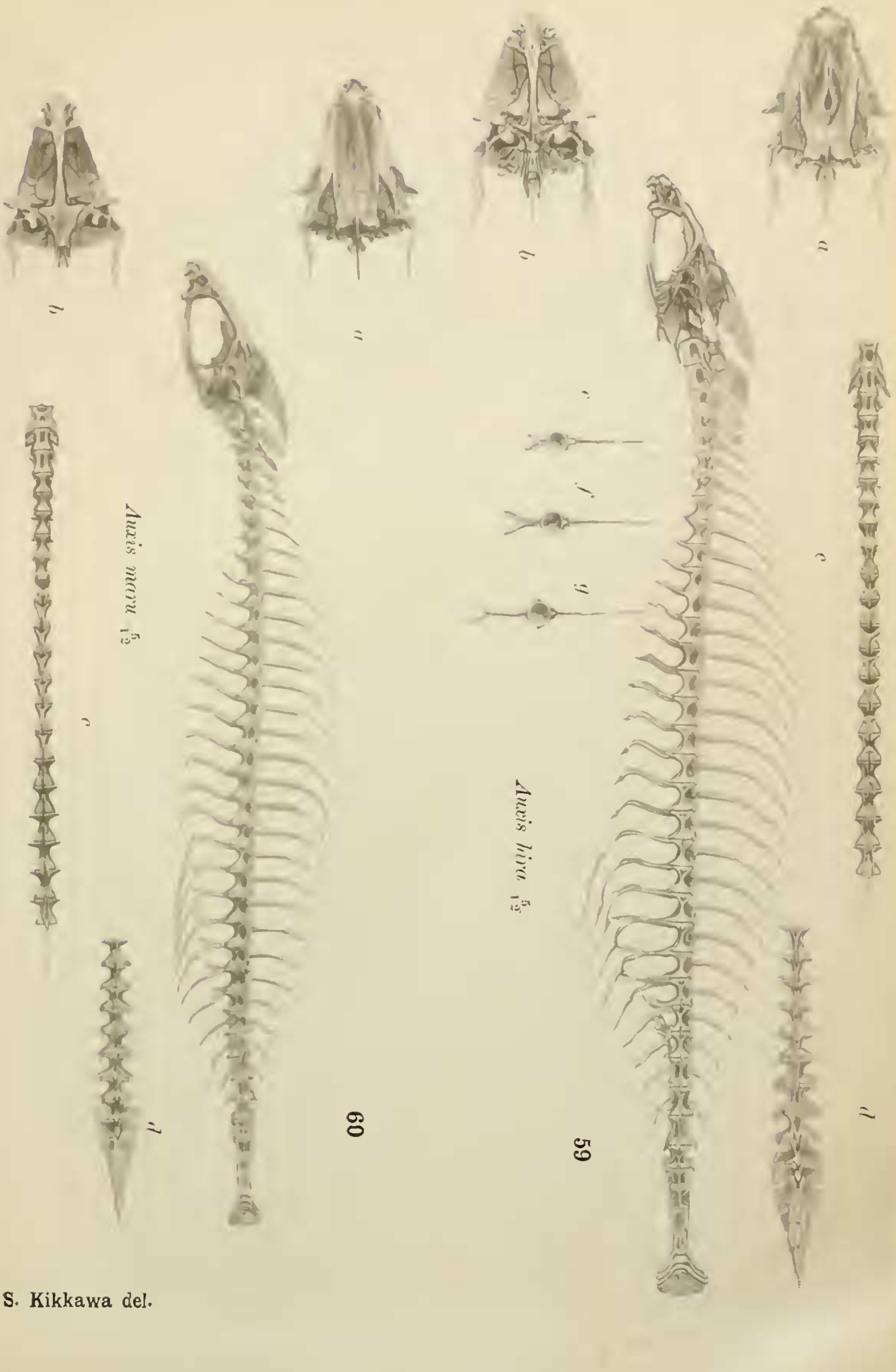
55

Auxis hira × 5

S. Kikkawa del.

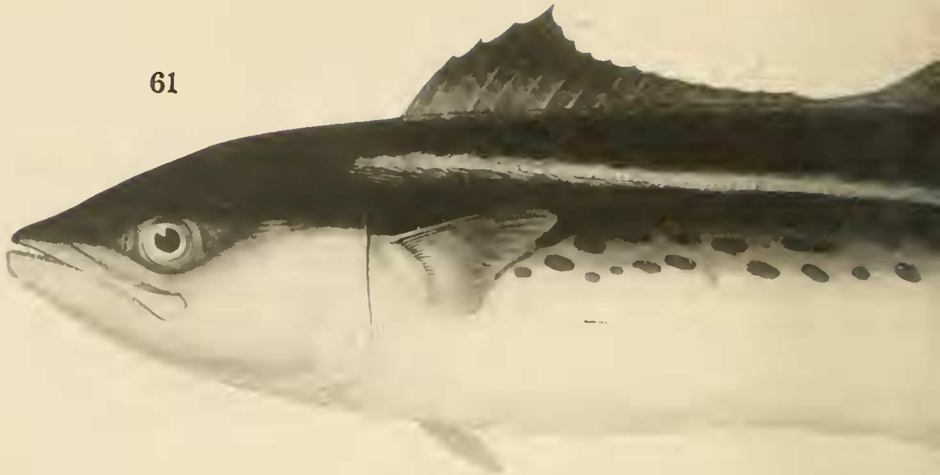


S. Kikkawa del.



S. Kikkawa del.

61



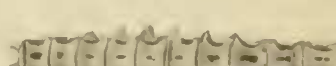
62

Grammatorcynus bilineatus $\frac{1}{2}$ $\frac{0}{3}$

a

64

c

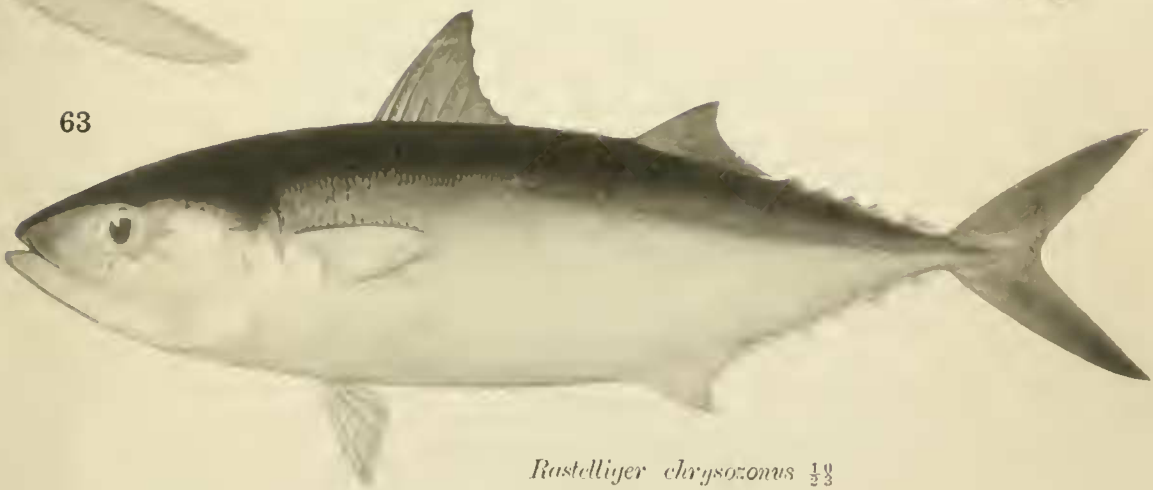


b

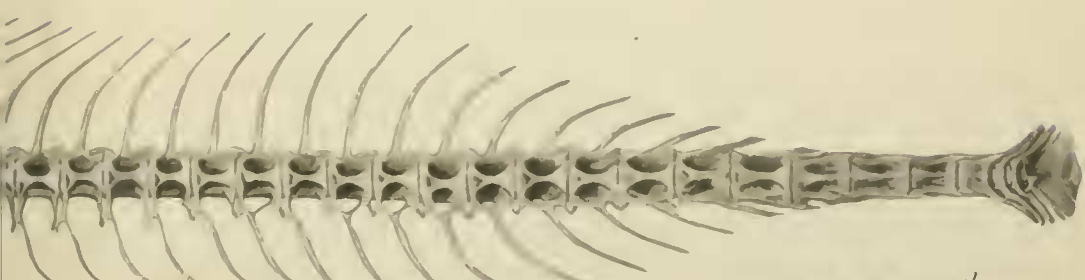
S. Kikkawa del.

Cybium guttatum $\frac{5}{11}$

63



Rastelliger chrysozonus $\frac{10}{23}$



unnus rarus